KEITHLEY

KEITHLEY

Model 2001 Multimeter

Operator's Manual

Contains Operating Information

KEITHLEY

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Model 2001 Multimeter
Operator's Manual

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean the instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument.

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1

General Information

1.1 Introduction

This section contains general information about the Model 2001 Multimeter. It is arranged in the following manner:

1.2 **Features**
1.3 **Warranty information**
1.4 **Manual addenda**
1.5 **Safety symbols and terms**
1.6 **Specifications**
1.7 **Inspection**
1.8 **Options and accessories**

1.2 Features

Some important Model 2001 features include:

- Full range of functions — Among other functions, the multimeter can measure DC voltage (normal and peak spikes), AC voltage (RMS, average, and peak), DC current (normal and in-circuit), AC current (RMS and average), two and four-wire resistance (normal and offset-compensated), frequency, and temperature (resistance temperature devices or thermocouples).
- Two-line display — Readings and front panel messages are shown on an alphanumeric display having a 20-character top line and a 32-character bottom line.
- Multifunction measuring and display — From the front panel, you can configure the instrument to sequentially measure and simultaneously display readings of multiple functions.
- Reading and setup storage — Readings and setup data can be stored and recalled from the front panel or over the IEEE-488 bus. For example, the buffer can be programmed to store up to 850 readings at 4.5 digits, or up to 250 time-stamped readings at 6.5 digits. The Model 2001 can be configured with memory options that extend the storage capacity up to 30,000 readings and ten setups.
- High-speed measurements — The instrument is capable of acquiring, for example, 2000 readings/second at 4.5 digits of resolution, and 215 readings/second at 6.5 digits.
- Talk-only mode — From the front panel, you can set the instrument to send readings to an IEEE-488 printer or, with an optional adapter, to a Centronics printer.
- Digital calibration — The instrument may be digitally calibrated from either the front panel or over the bus.
- Standard IEEE-488 interface — Bus operation conforms to the IEEE-488.2 and SCPI standards.
- Trigger link — This is a new trigger concept that provides more versatile and precise external triggering. It is in addition to the standard Trigger In/Measurement Complete BNC external triggering techniques.
- Optional field-installable internal scanner — This is a 10-channel scanner card, which includes eight channels of 2-pole relay switching and two channels of 2-pole solid-state switching. All channels can be configured for 4-pole operation.

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 2001 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to fill out and include the service form at the back of this manual to provide the repair facility with the necessary information.

1.4 Manual addenda

Any improvements or changes concerning the instrument or manual will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into the manual.

1.5 Safety symbols and terms

The following symbols and terms may be found on an instrument or used in this manual.

The symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

1.6 Specifications

Full Model 2001 specifications are included in Appendix A.

1.7 Inspection

The Model 2001 was carefully inspected, both electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit. (Note: There may be a protective film over the display lens, which can be removed.) Report any damage to the shipping agent immediately. Save the original packing carton for possible future reshipment. The following items are included with every Model 2001 order:

- Model 2001 Multimeter (with MEM1 or MEM2 memory option, if ordered) with line cord.
- Model 8605 High Performance Modular Test Leads.
- Model 2001 Operator's Manual and Model 2001 Calibration Manual.
- Accessories as ordered.
- Full calibration data (conforming to MIL-STD 45662A).

If an additional manual is required, order the appropriate manual package:

- Keithley part number 2001-900-00 for the Operator's Manual.
- Keithley part number 2001-905-00 for the Calibration Manual.
- Keithley part number 2001-902-00 for the Repair Manual.

The manual packages include a manual and any pertinent addenda.

1.8 Options and accessories

The following options and accessories are available from Keithley for use with the Model 2001.

Model 1050 Padded Carrying Case — A carrying case for a Model 2001 or a Model 7001. Includes handles and shoulder strap.

Models 2001/MEM1 and 2001/MEM2 — These optional configurations of the Model 2001 extend its storage capacity. The MEM1 option has 32K-bytes for non-volatile storage of five setups, and 7000 readings in compact format or 1400 readings in full format. The MEM2 option has 128K-bytes for non-volatile storage of ten setups, and 30000 compact readings or 6000 full readings.

Model 2001-SCAN — This is a 10-channel scanner card that installs within the Model 2001. It has eight channels of 2-pole relay switching and two channels of 2-pole solid-state switching. All channels can be configured for 4-pole operation. Included are two pairs of leads for connection to Model 2001 rear panel inputs (Keithley part number CA-109).

Model 4288-1 Single Fixed Rack Mount Kit — Mounts a single Model 2001 in a standard 19-inch rack.

Model 4288-2 Side-by-side Rack Mount Kit — Mounts two instruments (Models 182, 428, 486, 487, 2001, 7001) side-by-side in a standard 19-inch rack.

Model 4288-3 Side-by-side Rack Mount Kit — Mounts a Model 2001 and a Model 199 side-by-side in a standard 19-inch rack.

Model 4288-4 Side-by-side Rack Mount Kit — Mounts a Model 2001 and a 5-inch instrument (Models 195A, 196, 220, 224, 230, 263, 595, 614, 617, 705, 740, 775, etc.) side-by-side in a standard 19-inch rack.

Models 7007-1 and 7007-2 Shielded IEEE-488 Cables — Connect the Model 2001 to the IEEE-488 bus using shielded cables and connectors to reduce electromagnetic interference (EMI). The Model 7007-1 is one meter long; the Model 7007-2 is two meters long.

Models 8501-1 and 8501-2 Trigger Link Cables — Connect the Model 2001 to other instruments with Trigger Link connectors (e.g., Model 7001 Switch System). The Model 8501-1 is one meter long; the Model 8501-2 is two meters long.

Model 8502 Trigger Link Adapter — Allows you to connect the Trigger Link of the Model 2001 to instruments that use the standard BNC (In/Out) external triggering technique.

Model 8530 IEEE-488 to Centronics Printer Adapter Cable — Translates the IEEE-488 connector pinout and signal level to a Centronics termination. This permits a standard Centronics parallel printer to be connected to a Model 2001 in TALK-ONLY mode.

Model 8605 High Performance Modular Test Leads — Consists of two high voltage (1000V) test probes and leads. The test leads are terminated with a banana plug with retractable sheath on each end. (Each Model 2001 is shipped with one set of these test leads.)

Model 8606 High Performance Probe Tip Kit — Consists of two spade lugs, two alligator clips, and two spring hook test probes. (The spade lugs and alligator clips are rated at 30V RMS, 42.4V peak; the test probes are rated at 1000V.) These components are designed to be used with high performance test leads terminated with banana plugs, such as the Model 8605 High Performance Modular Test Leads.

The following test leads and probes are rated at 30V RMS, 42.4V peak:

Models 5805 and 5805-12 Kelvin Probes — Consists of two spring-loaded Kelvin test probes with banana plug termination. Designed to be used with instruments that measure 4-terminal resistance. The Model 5805 is 0.9m long; the Model 5805-12 is 3.6m long.

Model 5806 Kelvin Clip Lead Set — Includes two Kelvin clip test leads (0.9m) with banana plug termination. Designed for instruments that measure 4-terminal resistance. A set of eight replacement rubber bands for the Model 5806 is available as Keithley P/N GA-22.

Model 8604 SMD Probe Set — Consists of two test leads (3ft), each terminated with a surface mount device "grabber" clip on one end and a banana plug with retractable sheath on the other end.

Model 8610 Low Thermal Shorting Plug — Consists of four banana plugs mounted to a 1-inch square circuit board, interconnected to provide a short circuit among all plugs.

Model 8611 Low Thermal Patch Leads — Consists of two test leads (3ft), each with a banana plug with a retractable sheath at each end. These leads minimize the thermally-induced offsets that can be created by test leads.

Model 8612 Low Thermal Spade Leads — Consists of two test leads (3ft), each terminated with a spade lug on one end and a banana plug with a retractable sheath on the other end. These leads minimize the thermally-induced offsets that can be created by test leads.

Model 8680 RTD Probe Adapter — This adapts RTDs with terminated and unterminated cables to instruments with banana jacks for measuring 4-terminal resistance. It has a 4-pin "T"-style connector and a 4-pin screw terminal block.

Model 8681 Miniature RTD Surface Probe — This is a low cost platinum 4-wire-RTD with unterminated wires. It is designed to measure the temperature of flat surfaces or free space.

Model 8693 General Purpose/Immersion RTD Probe — This probe has a platinum RTD sensor. It is designed for immersion in liquids as well as other general purpose applications.

Model 8695 Surface RTD Probe — This probe has a platinum RTD sensor. It is designed to measure the temperature of flat surfaces of solids.

Model 8696 Air/Gas RTD Probe — This probe has a platinum RTD sensor. It has an exposed junction within a protective shroud for measuring the temperature of air or gases.

2

Getting Started

2.1 Introduction

This section contains introductory information on operating your Model 2001 Multimeter. For detailed front panel and IEEE-488 bus operation, refer to Sections 3 and 4 respectively.

The information in this section is arranged as follows:

2.2 **Front and rear panel summary:** Describes the controls and connectors on the front and rear panels, and the front panel display of the instrument.

2.3 **Overview of measurement process:** Provides a brief description of the measurement process.

2.4 **Initial configuration:** Reviews initial configuration information that should be considered before operation.

2.5 **Front panel operation:** Demonstrates basic front panel operation through the use of simple examples.

2.6 **IEEE-488.2 and SCPI basics:** Discusses fundamental information concerning operation over the IEEE-488 bus, including programming examples.

NOTE

The IEEE-488 bus is also referred to as GPIB, the general purpose interface bus. Both terms are used with the Model 2001 and in this manual.

The Keithley Applications Department is available at 1-800-348-3735 (U.S. only) to answer any questions about the Model 2001.

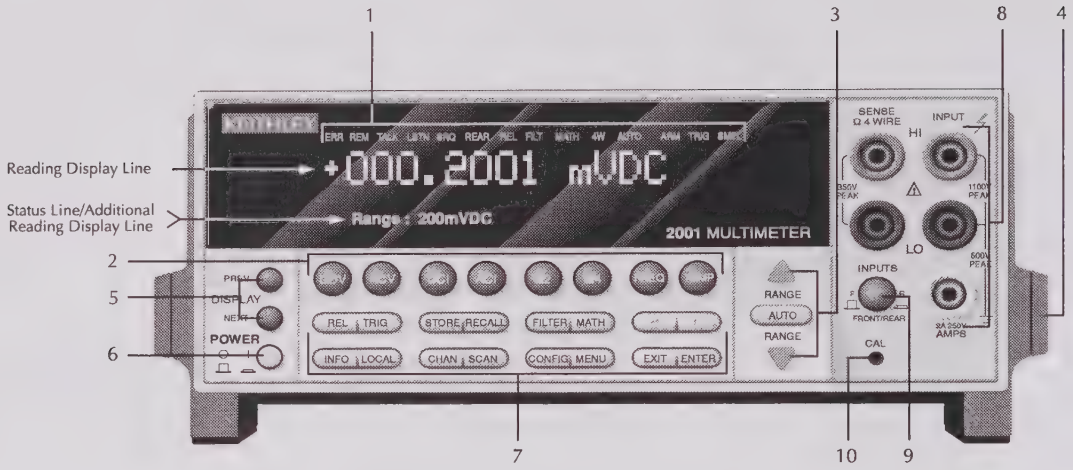
2.2 Front and rear panel summary

2.2.1 Front panel

The front panel controls and connections of the Model 2001 are shown in Figure 2-1. This figure includes important abbreviated information that should be reviewed before operating the instrument. Notice that some of the controls are dual-function, rocker-action type keys. These include REL/TRIG, STORE/RECALL, FILTER/MATH, ◄/►, INFO/LOCAL, CHAN/SCAN, CONFIG/MENU, and EXIT/ENTER.

2.2.2 Rear panel

The rear panel of the Model 2001 is shown in Figure 2-2. This figure also includes abbreviated information that should be reviewed before operating the instrument.



1 ANNUNCIATORS
ERR: Questionable reading (see paragraph 4.21)
REM: In remote
TALK: Addressed to talk
LSTN: Addressed to listen
SRQ: Service Request
REAR: Reading acquired from rear inputs
REL: Relative reading displayed
FILT: Digital filter enabled
MATH: Math calculation enabled
4W: 4-wire resistance reading displayed
AUTO: Autoranging enabled
ARM: Trigger armed; not in idle.
*(asterisk): Readings being stored

2 FUNCTION KEYS

DCV: DC voltage	Ω2: 2-wire resistance
ACV: AC voltage	Ω4: 4-wire resistance
DCI: DC current	FREQ: Frequency
ACI: AC current	TEMP: Temperature

3 RANGE KEYS
▲: Moves to higher range; increments digit
▼: Moves to lower range; increments digit
AUTO: Enables/disables autorange

4 HANDLE (not shown)
Pull out and rotate to desired position

5 DISPLAY KEYS
PREV: Moves to previous multiple display of a function
NEXT: Moves to next multiple display of a function

6 POWER
0 = OFF
1 = ON

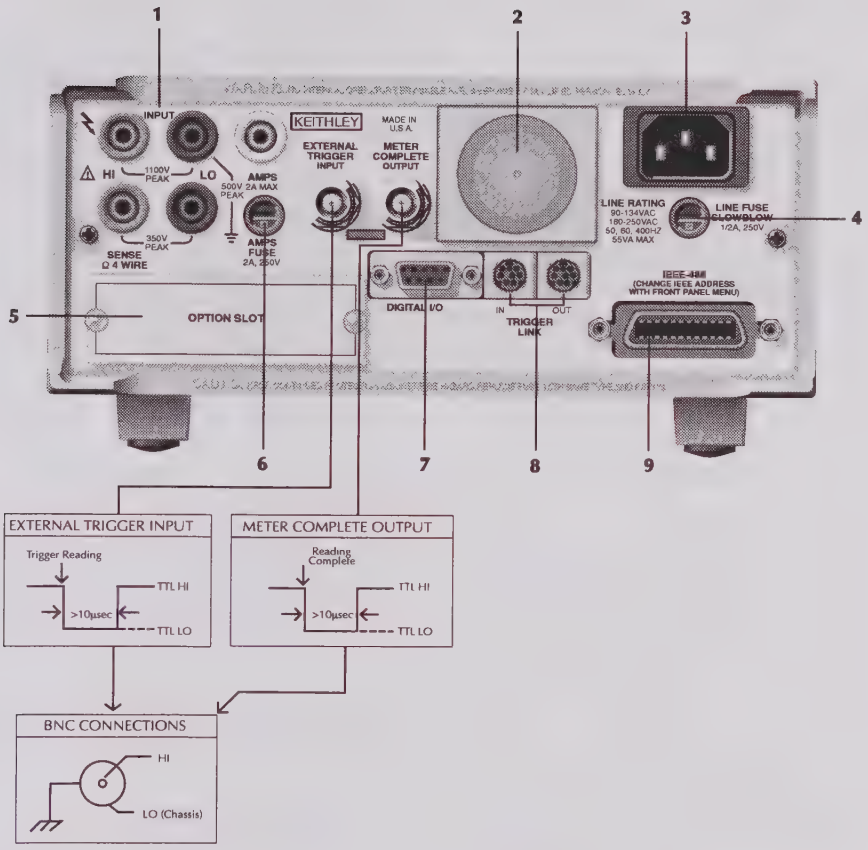
7 OPERATION KEYS
REL: Enables/disables relative reading
TRIG: Triggers unit
STORE: Enables data storage
RECALL: Displays reading data (reading, number, time). Use PREV/NEXT DISPLAY for maximum
FILTER: Displays digital filter status for present function and toggles filter on/off
MATH: Displays math calculation and toggles math on/off if configured
◀ and ▶ : Moves cursor among data entry digits, menu selections, and information displays
INFO: Shows context-sensitive information about the present display
LOCAL: Cancels IEEE-488 remote
CHAN: Selects internal scanner channel to measure (1-10)
SCAN: Performs scan of internal or external scanner channels, or ratio or delta
CONFIG: Configures functions and operations
MENU: Saves/restores instrument conditions; sets up GPIB; performs calibration and self-tests; defines limits, buffer, digital I/O, autozero
EXIT: Cancels selection, moves back within menu structure
ENTER: Holds reading, enters selection, moves down within menu structure

8 INPUT CONNECTIONS
INPUT HI and LO: Used for making DC volts, AC volts, and 2-wire resistance measurements
AMPS: Used in conjunction with INPUT LO to make DC current and AC current measurements. Also holds current input fuse (2A, 250V, fast blow, 5×20mm)
SENSE Ω4 WIRE HI and LO: Used with INPUT HI and LO to make 4-wire resistance measurements

9 INPUTS
Selects input connections on front or rear panels

10 CAL
Enables calibration functions

Figure 2-1
Model 2001 front panel



1 INPUT CONNECTIONS

INPUT HI and LO: Used for making DC volts, AC volts, and 2-wire resistance measurements.

AMPS: Used in conjunction with INPUT LO to make DC current and AC current measurements.

SENSE Ω4 WIRE HI and LO: Used with INPUT HI and LO to make 4-wire resistance measurements

2 FAN

Keep filter clean to ensure proper instrument cooling.

3 POWER LINE INPUT

90-134VAC and 180-250VAC (universal); 50, 60, or 400Hz (self-identifying)

WARNING: Connect to grounded outlet using 3-wire power cord.

4 LINE FUSE

Provides protection on the AC power line, Replace only with 0.5A, 250V, slow blow, 5×20mm

5 SCANNER

Optional Model 2001-SCAN Scanner Card installs in this slot

6 AMPS FUSE

Holds current input fuse (2A, 250V, fast blow, 5×20mm)

7 DIGITAL I/O

A DB-9 connector for the TTL-compatible digital I/O with on input and four outputs

8 TRIGGER LINK IN and OUT

Two 8-pin micro DIN connectors for sending and receiving trigger pulses among other instruments. (See paragraph 3.7.7)

9 IEEE-488 CONNECTOR

Connects the instrument to the IEEE-488 (GPIB) bus. NOTE: Use shielded IEEE-488 cables

Figure 2-2
Model 2001 rear panel

2.2.3 Front panel display

Normal displays

In the normal display mode, the front panel of the Model 2001 shows the following:

- Top line — Readings, units, and channel number if scanning. Where needed for clarification, the type of measurement.
- Bottom line — Range, if fixed; ACV and ACI coupling; frequency coupling and terminals; temperature sensor.

Most readings have from 3.5 to 7.5 digits of resolution. For example, an AC voltage measurement (RMS type), at 5.5 digits on the 200VAC range would be displayed as follows:

```
+000.000 VAC RMS
Range: 200 VAC   Coupling: AC
```

With a math operation enabled (percent or mX+b), the reading could be expressed in scientific notation, such as:

```
+5.0000e+03 VAC %
Range: 200 VAC   Coupling: AC
```

Multiple displays

The mode called multiple display is accessed from the normal display by pressing the NEXT or PREVious DISPLAY keys. Each measurement function has its own set of multiple displays.

In the multiple display mode, the Model 2001 can show the readings of up to three separate measurements. For example, in the DC voltage function, one of the multiple displays shows DC volts, AC ripple voltage, and ripple frequency:

```
+00.00000 VDC
+00.0000 VAC    +000.00 Hz
```

Or, a multiple display can show a bar graph, such as:

```
+12.00000 VDC
0|=====|=====|==   |    |+20V
```

The complete set of multiple displays is listed in Appendix H. They are described in detail in Section 3. The set for the DC voltage function is also shown in Table 2-1.

INFO displays

There are context-sensitive information message displays for most front panel operations. The explanatory information is toggled on and off with the INFO key. For example, the INFO message for one of the DCV multiple displays is:

```
INFO: VDC, VAC, Hz
Shows DC value, AC ripple, and ▶
◀ the ripple frequency.
```

where the blinking ◀ and ▶ characters signify that the front panel cursor keys must be used to view the complete bottom line.

INFO messages are listed in Appendix H.

Configuration menu displays

Each measurement function is individually configured by pressing CONFIG followed by the function key. In addition, operations that affect all measurement functions, such as triggers, data storage, and limits, are also configured by pressing CONFIG followed by the operation key.

The top level of the configuration menu for DC voltage is accessed by pressing the CONFIG key, and then the DCV key. The resulting display reads:

```
CONFIGURE DCV
SPEED   FILTER   RESOLUTION
```

In some cases, menu selections branch off to further define the options, such as the following for the SPEED option:

```
DCV MEASUREMENT SPEED
NORMAL   FAST   MEDIUM   HIACCURACY ▶
◀ SET-SPEED-EXACTLY   SET-BY-RSLN
```

Configuration menus for all functions and operations are shown in Appendix H. Guidelines for navigating the front panel menus are summarized in Table 2-2.

Table 2-1
DCV multiple displays

Display	Description
+00.00000 VDC Range: 20 VDC NEXT ↓ ↑ PREV	Normal display. (Range not shown if auto-range.)
+00.00000 VDC +00.0000 VAC +000.00 Hz NEXT ↓ ↑ PREV	AC ripple voltage and frequency.
+00.00000 VDC Pos-Pk=+00.00 V Highest=+00.00 V NEXT ↓ ↑ PREV	Positive peak spikes and highest value.
+00.00000 VDC Neg-Pk=+00.00 V Lowest=+00.00 V NEXT ↓ ↑ PREV	Negative peak spikes and lowest value.
+00.00000 VDC Pos-Pk=+00.00 V Neg-Pk=+00.00 V NEXT ↓ ↑ PREV	Positive and negative peak spikes.
+10.00000 VDC 0|=====|=====| | |+20V NEXT ↓ ↑ PREV	Bar graph to + or - full scale.
+10.00000 VDC -50% | | |====|====| +50% NEXT ↓ ↑ PREV	Zero-centered bar graph with adjustable limits.
+00.00000 VDC Max=+00.00000 Min=+00.00000 NEXT ↓ ↑ PREV	Maximum and minimum values.
+00.00000 VDC Actual=+00.00000 (without REL) NEXT ↓ ↑ PREV	Value with REL applied. Actual value.
+00.00000 VDC Reading=+00.00000 NEXT ↓ ↑ PREV	Result of math operation. Reading before math.
+00.00000 VDC PASS LLIM1| | |====| |HLIM1 NEXT ↓ ↑ PREV	HI/LO/PASS bar graph with adjustable limits.
+00.00000 VDC CH02 CH01=+00.0000 V CH03=+00.0000 V NEXT ↓ ↑ PREV	Readings of adjacent internal channels (with Model 2001-SCAN option).

Note: Press the NEXT and PREV DISPLAY keys to scroll through the multiple displays (with wraparound).

Table 2-2
Menu summary

Action	Description
CONFIG-DCV	Press the CONFIG key, then the DCV key, to view the top level of the DCV configuration menu. Access to other function and operation configurations are similar, e.g., CONFIG-ACV or CONFIG-TRIG.
MENU	Press the MENU key to view the top level of the main menu. The operations that have no corresponding key are included in the main menu.
◄ or ►	Use the cursor keys to move the highlighted cursor among menu selections, or the digits of a parameter value, or change channels on the scanner.
RANGE ▲ RANGE ▼	Use the RANGE keys to increment and decrement digits of a parameter value.
ENTER	Accepts menu selection or data entry.
EXIT	Cancels changed menu selection. Also returns you to the previous menu level.
INFO	Displays context-sensitive information about the present menu level. Toggles information message on/off.

Buffered readings display

After readings have been stored in the buffer, they are displayed on the front panel by pressing the RECALL key. This action brings up the first reading in the buffer, such as:

+00.00000 VDC
Rdg#+00000 @Time=+000.000000 sec

where the top line shows the reading, and the bottom line shows the reading number and time-stamp. The RANGE ▲ and ▼ keys scroll through the readings and the ◄ and ► keys change the digit being scrolled. You can scroll through statistical data on the buffered readings by pressing the NEXT and PREVious DISPLAY keys. This also gives you the option of printing the data.

NOTE

Buffered readings are preserved across power transition when the memory options are installed.

Message displays

While operating the Model 2001, the front panel display is also used for showing status and error messages. These messages are shown to inform you of parameter conflicts, trigger overruns, etc. Refer to paragraph 3.3.4 for a complete list of these messages.

Section 4, IEEE-488 Reference, describes the programming of user messages to be shown on the front panel. (See the DISPlay subsystem.) Both lines of the display are available for this purpose.

2.3 Overview of measurement process

The following overview is intended to acquaint you with the basic measurement fundamentals without overwhelming you with the details of enhanced capabilities. This brief overview is sufficient to support the operation examples in paragraphs 2.5 (front panel) and 2.6 (IEEE-488 bus). For a complete explanation on all aspects of the measurement process, see paragraph 3.7.

The simplified model for a measurement operation is shown in Figure 2-3. As shown, the measurement operation consists of three layers: the arm layer, scan layer, and measure layer.

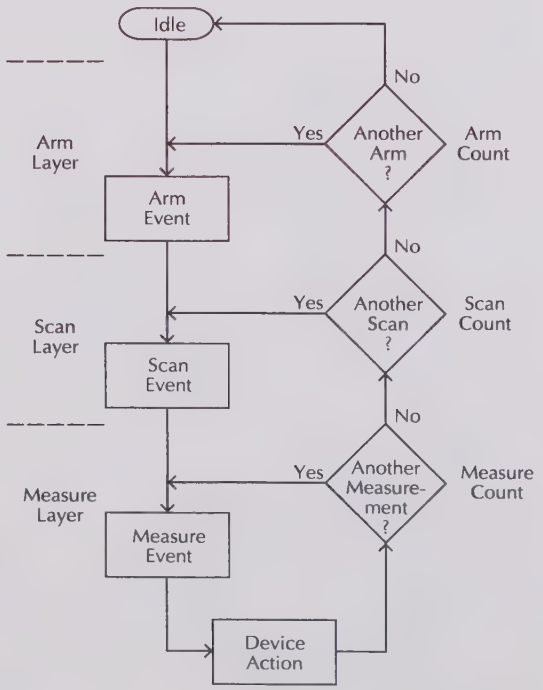


Figure 2-3
Simplified model of measurement operation

2.3.1 Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the model. The front panel ARM indicator is off when the instrument is in the idle state.

When the Model 2001 is taken out of the idle state by pressing TRIG (or sending the :INIT or :INIT:CONT ON command over the IEEE-488 bus), the ARM indicator turns on and operation proceeds into the arm layer.

2.3.2 Arm layer

In general, the instrument requires an arm event to allow operation to proceed to the scan layer. With an arm source of Immediate (the factory default), operation immediately proceeds to the next layer when the instrument is taken out of the idle state. With one of the other arm sources selected, the instrument waits until the appropriate event occurs, as explained below:

- External — The instrument waits for an input trigger (via EXTERNAL TRIGGER connector on rear panel).
- Manual — The instrument waits until the front panel TRIG key is pressed.
- GPIB — The instrument waits until a bus trigger (GET or *TRG) is received.
- Trigger Link — The instrument waits until an input trigger is received (via TRIGGER LINK).
- Hold — The instrument waits in the arm layer until the arm source is changed. (Note: the signal and immediate layer commands, that is, :ARM:LAY1:SIGN and :ARM:LAY1:IMM, will satisfy the event detection logic.)

After all scan and measure operations are complete, the instrument can be returned to the arm layer by programming the instrument for additional arms. The arm count can be set to a finite value (1 to 99,999) or to infinity. The factory default value is one.

After the instrument leaves the arm layer, operation proceeds into the scan layer.

2.3.3 Scan layer

In general, the instrument requires a scan event to allow operation to proceed to the measure layer. With a scan source of Immediate (the factory default), operation immediately proceeds to the next layer. With one of the other scan sources selected (External, Manual, GPIB, Trigger Link, Timer, or Hold), the instrument waits until the appropriate event occurs.

With a scan source of Timer, the first pass through the scan layer occurs immediately. If programmed for additional scans, the instrument waits for an interval between 1msec and 999,999.999 seconds.

The scan count (number of scans) can be set to a finite value (1 to 99,999) or to infinity. The "bench" factory default value is infinity.

After the instrument leaves the scan layer, operation proceeds into the measure layer.

2.3.4 Measure layer

In general, measure events control the reading rate. With a measure source of Immediate (the factory default), a device action occurs immediately. The device action consists of taking a reading. If scanning is selected, the device action consists of taking a reading, opening a channel, configuring for next function in scan list, and closing a channel.

With one of the other measure sources selected (External, Manual, GPIB, Trigger Link, Timer, or Hold), the instrument waits until the appropriate event occurs before taking a reading and, optionally, scanning a channel.

With a measure source of Timer, the first reading is taken immediately. Each additional reading waits for the Timer to time out before it is taken.

The measure count (number of readings to take) is set to a finite value (1 to 99,999) or to infinity. The factory default value is infinity.

In factory default conditions, the arm layer and scan layer are transparent to the measurement operation.

2.4 Initial configuration

WARNING

Before turning on the Model 2001, make sure it is connected to a grounded power receptacle using the supplied power cord or the equivalent. Failure to properly ground the unit creates a shock hazard that could result in injury or death.

The Model 2001 can save from one to ten user setups in memory, depending on the installed memory option. You can select one of the user setups as the power-on default, or have the instrument power up to either of the two factory defaults (optimized for "BENCH" or "GPIB" operation). Since the examples in paragraph 2.5 assume BENCH defaults, reset the instrument to those settings by performing the following steps:

1. Press the MENU key to display the MAIN MENU options as shown below:

   MAIN MENU
   SAVESETUP GPIB CALIBRATION ►
   ◄ TEST LIMITS STATUS-MSG GENERAL

   When the lower display line is longer than one line, the right-most character will be a ► symbol. Repeatedly press the ► key to view the second half of the lower line, and press the ◄ key to return to the first half display.

   NOTE

   Additional information is available for most front panel operations. Simply press the INFO key to toggle an INFO display. Use the ◄ and ► keys to see the complete lower line.

2. If the SAVESETUP option is not blinking, press the ◄ key until it is and then press ENTER to view the setup menu:

   SETUP MENU
   SAVE RESTORE POWERON RESET

3. Press the ► key until the RESET option of the SETUP MENU is blinking and then press ENTER to view the reset menu:

   RESET ORIGINAL DFLTS
   BENCH GPIB

4. Select the BENCH option by making it blink and pressing ENTER. The following confirmation message is displayed:

   RESETTING INSTRUMENT
   ENTER to confirm; EXIT to abort

5. Press ENTER to confirm. The parameters accessed by the front panel are now reset to factory defaults for bench operation. The display will show DC voltage readings with autorange enabled. The default settings for DC voltage are:

   - Measurement speed (integration time) — Normal, 1 power line cycle.
   - Digital filter — Advanced, 10 readings, 1% noise tolerance, moving average, enabled.
   - Display resolution — 6.5 digits.

2.5 Front panel operation

Basic front panel operation will be demonstrated by examples of measuring DC voltages. The first example shows readings at default settings and high accuracy readings. The second example shows storing high speed readings. These examples are only intended to teach basic operation.

Details for using the full capabilities of the Model 2001 from the front panel are contained in Section 3 of this manual. The manual for the Model 2001-SCAN Scanner Card has examples for closing and opening channels and scanning lists of channels.

NOTE

The front panel operation examples assume that the Model 2001 is initially set up for proper operation as explained in paragraph 2.4.

2.5.1 Measuring DC voltage example

Before starting this example, the front panel display should show triggered DC voltage measurements. If it does not, perform a bench reset following the procedure of paragraph 2.4.

Perform the following steps to make DC voltage measurements with the Model 2001 Multimeter.

Step 1 — Connect a DC voltage source

The Model 2001 can be used to make DC voltage measurements in the range of ±10nV to ±1100V. Low level measurement techniques need to be used at resolutions of 5.5 digits and more. See paragraph 3.4.1 for low level measurement considerations.

WARNING

The maximum input voltage between INPUT HI and INPUT LO is 1100V peak. The maximum common-mode voltage (voltage between INPUT LO and chassis ground) is 500V peak. Exceeding these values may create a shock hazard.

1. Select the front input jacks with the INPUTS button (outer position for front jacks, inner position for rear).
2. Using the set of supplied test leads, connect the Model 2001 to a DC voltage source (e.g., a battery) as shown in Figure 2-4.

Step 2 —Select a range and display a reading

Use the RANGE keys to select autoranging or a manual range:

1. As indicated by the AUTO annunciator, bench reset returns the instrument to autoranging. Pressing the AUTO range key toggles autoranging.
2. You can select a different range with the ▲ RANGE and ▼ RANGE keys. When using manual ranging, be sure to use a range high enough for the signal level. If the "Overflow" message is displayed on a manual range, select the next higher range until you obtain an on-range reading. Use the lowest possible range to obtain the best accuracy and resolution.
3. For the 200mV range, short the probe ends and allow the reading to settle. Press REL to null any offsets. Leave REL enabled while making measurements. Reconnect the probes to the voltage source.

NOTE

A reading can be held by pressing the ENTER key. This freezes the display until the EXIT key is pressed, returning the display to normal. If the ENTER key is pressed instead, the display is updated with another reading.

Step 3 —View the default configuration

The DCV function has the following defaults for speed, filter, and resolution:

- Measurement speed (integration time) — Normal (1 power line cycle; 16.7msec for 60Hz, 20msec for 50Hz and 400Hz).
- Digital filter — Advanced, 10 readings, 1% noise tolerance, moving average, enabled.
- Display resolution — 6.5 digits.

If these settings are not sufficient for your DCV measurement, they can be changed through the DCV configuration menu:

1. Press the CONFIG key and then the DCV or ENTER key. The instrument displays the following menu:

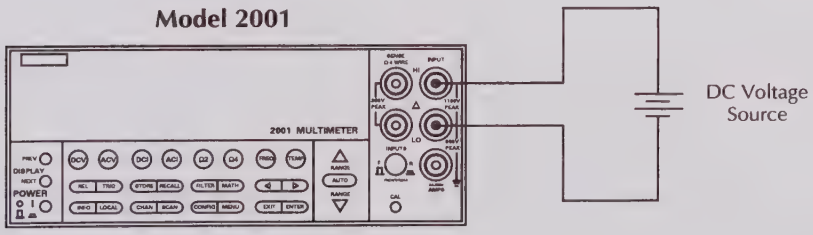
   CONFIGURE DCV
   SPEED FILTER RESOLUTION

NOTE

Pressing CONFIG, then ENTER displays the top level of the configuration menu for the present function.

2. You can view the present selections of each CONFIGURE DCV option by pressing the ◄ and ► keys to move to the desired option, then pressing ENTER. The present selection is shown blinking. (Remember that additional information is available by pressing the INFO key.)

This is the top level of the menu shown in Table 2-3.



Input Resistance = 10MΩ on 1000V and 200V ranges ;
> 10GΩ on 20V, 2V and 200mV ranges.
= 1MΩ on DCV peak spikes measurement.

Caution: Maximum Input = 1100V peak

Figure 2-4
Typical DC voltage connections

Table 2-3
CONFIGURE DCV menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.

Step 4 —Configure for high accuracy

To make high accuracy readings of a voltage source, change the configuration of the DC voltage measurement, as follows:

1. Select SPEED from the CONFIGURE DCV menu, then press ENTER. The multimeter displays the following menu:

   DCV MEASUREMENT SPEED
   NORMAL FAST MEDIUM HIACCURACY ▶
   ◀ SET-SPEED-EXACTLY SET-BY-RSLN

2. Using the cursor keys, select the HIACCURACY option (integration time of 10 power line cycles), then press ENTER.

3. Select FILTER from the CONFIGURE DCV menu, then press ENTER. The following menu is displayed:

   DCV DIGITAL FILTER
   AUTO AVERAGING ADVANCED ▶
   ◀ AVERAGING-MODE

4. Using the cursor keys, select the AVERAGING option, then press ENTER. The instrument displays the following:

   AVG: 010 RDGS (1-100)
   Use ◀ , ▶ , ▲, ▼, ENTER,EXIT, or INFO

5. This is a simple moving average filter of 10 readings, which is the minimum recommended for high accuracy DC voltage measurements. If it is sufficient, just press ENTER or EXIT. If you want the instrument to average more readings, use the cursor keys and RANGE keys to increase the value (up to 100 readings). Press ENTER to make the change.

   NOTE

   This step does not enable the digital filter. That is done by pressing the FILTER key while outside the menu structure.

6. Select RESOLUTION from the CONFIGURE DCV menu. The following menu is displayed:

   SET DCV RESOLUTION
   AUTO 3.5d 4.5d 5.5d 6.5d 7.5d

7. Using the cursor keys, select 7.5 digits of resolution, then press ENTER.

8. Press EXIT to return to the normal display. The reading should reflect the speed and resolution changes. (Changes will affect only the DCV function.)

Step 5 —Enable the digital filter

If the filter is not on, press FILTER to enable the digital filter. The type of filter and number of readings selected is displayed momentarily, for example:

Filter Enabled
Digital = AVG(10)

The reading should now be less noisy. The digital filter can be disabled by pressing the FILTER key again.

Step 6 —View the multiple displays

Each measurement function has a series of front panel displays. The displays are accessed with the NEXT DISPLAY and PREV DISPLAY keys.

1. From the normal display of DC voltage, press the NEXT DISPLAY key once to also view AC voltage and frequency measurements of the signal, for example:

   +000.0000 mVDC
   +000.000 mVAC +000.00 Hz

2. Return to the normal DCV display by pressing PREV DISPLAY, or view the remaining DCV displays by pressing NEXT DISPLAY, which wraps around to the normal display. The DC voltage multiple displays were shown in Table 2-1.

NOTE

Pressing and holding either the NEXT DISPLAY or PREV DISPLAY key returns to the normal display.

2.5.2 Storing DC voltage readings example

This example assumes the Model 2001 is reset to its bench defaults, as outlined in paragraph 2.4. It also assumes the instrument is connected to a DC voltage source, and the front panel displays on-scale readings.

Step 1 —Configure for high speed measurements

To make high speed readings of a voltage source, change the configuration of DC voltage measurements, as follows:

1. Press CONFIG-DCV to view the DCV configuration menu:

   CONFIGURE DCV
   SPEED FILTER RESOLUTION

2. Select SPEED from the menu, then press ENTER. The multimeter displays the following menu:

   DCV MEASUREMENT SPEED
   NORMAL FAST MEDIUM HIACCURACY ▶
   ◀ SET-SPEED-EXACTLY SET-BY-RSLN

3. Using the cursor keys, select the FAST option, then press ENTER. Since the resolution is set to AUTO, where it defaults to a value appropriate for the speed, it will be set to 4.5d automatically.

4. Press EXIT to return to the normal display.

Step 2 —Store the readings

To store readings in the instrument's data storage buffer, perform the following:

1. Press the STORE key. The following message is displayed:

   STORE 00100 READINGS
   Use ◀ , ▶ , ▲, ▼, ENTER,EXIT, or INFO

2. The factory default number of readings to store is 100. Use the cursor and RANGE keys to make changes. The maximum possible number of readings depends on the following:

   - The data group selected for storage (full or compact). This is selected under the CONFIG DATA STORE menu.
   - The memory option (STD, MEM1, or MEM2).

3. Press ENTER to start storing readings. The asterisk annunciator lights to indicate a data storage operation. The bottom line of the display counts up the data storage points.

Step 3 —Recall the readings

To recall the stored readings, perform the following:

1. Press RECALL to view the readings. The following message is displayed with the cursor on the least significant digit of the reading number:

   +00.00000 VDC
   Rdg#+00000 @Time=+000.000000 sec

2. Use the RANGE ▲ and ▼ keys to increment and decrement the reading number and scroll through the buffer.

3. The NEXT and PREV DISPLAY keys can be used while recalling readings to access additional data, as shown in Table 2-4.

Table 2-4
Multiple displays for recalled readings

Display	Description
+00.00000 VDC Rdg#+00000 @Time=+000.000000 sec NEXT ↓ ↑ PREV	Normal stored reading. Reading number and time-stamp.
+00.00000 VDC MAX=+0.000000e+00 at RDG# +00000 NEXT ↓ ↑ PREV	Maximum value of stored readings.
+00.00000 VDC MIN=+0.000000e+00 at RDG# +00000 NEXT ↓ ↑ PREV	Minimum value of stored readings.
+00.00000 VDC AVG=+0.0000e+00 SDEV=+0.0000e+00 NEXT ↓ ↑ PREV	Average and standard deviation.
PRINT BUFFER DATA Press ENTER to start printing. NEXT ↓ ↑ PREV	Prompt to dump readings to a printer.

Note: Press the NEXT and PREV DISPLAY keys to scroll through the multiple displays (with wraparound.)

Step 4 —Configure for burst of high speed readings

There are two data acquisition modes, normal and burst. The burst reading rate is 2000 readings/sec into the buffer (plus post-processing time of the raw readings, typically 2msec/reading). To achieve this speed, certain tradeoffs are made with flexibility, as listed in Table 2-5.

1. To continue the reading storage example with burst mode selected, display the CONFIG DATA STORE menu by pressing the CONFIG key, then the STORE key:

   CONFIG DATA STORE
   BURST-MODE DATA-GROUP CONTROL ▶
   ◀ CLEAR-ALL COUNT FEED

2. Select BURST-MODE and press ENTER. After a momentary message about clearing the buffer, the display shows:

   BURST MODE
   OFF ON

3. Select ON and press ENTER. (Certain instrument parameters are saved when burst is enabled, and are restored when burst is disabled. See paragraph 3.8.1 for further details on burst mode.)

Table 2-5
Burst mode availability

Function/operation	Setting
DC voltage	Normal (no peak spikes)
AC voltage	Normal RMS or average
DC current	Normal (no in-circuit)
AC current	RMS or average
2-wire resistance	Normal (no offset compensation)
4-wire resistance	Not available
Frequency	Not available
Temperature	Not available
Range	Fixed
Autozero	Disabled
Speed	FAST (0.01 PLC)
Filter	Repeat acts like moving.
Resolution	4.5 digits
Multiple displays	Disabled
Data grouping	Compact (reading and reading number)
Delay	As set.

Notes:
1. The measurement display is not updated during burst.
2. A math operation slows post-processing time.

4. The next message sets the number of burst readings to store:

   BURST: 00100 READINGS
   Use ◄ , ► , ▲, ▼, ENTER,EXIT, or INFO

5. Use the cursor and RANGE ▲ and ▼ keys to change the buffer size. Then press ENTER for the change to take effect:

   00100 READING BURST
   Use TRIG to start; EXIT to abort

Step 5 —Acquire the burst readings

Initiate burst mode by pressing the TRIG key.

The ARM annunciator comes on when the raw readings are being acquired. The asterisk annunciator comes on when the readings are being post-processed. Both indicators go out when post-processing is complete.

Step 6 —Recall the burst readings

1. Examine the contents of the buffer by pressing RECALL:

   +00.000 VDC
   Rdg#+00000

2. Press the EXIT key once to leave the buffer contents display. Press it a second time to disable the burst mode.

2.6 IEEE-488.2 and SCPI basics

The following paragraphs discuss fundamental information concerning operation over the IEEE-488 bus. Detailed information on operating the instrument over the bus is contained in Section 4 of this manual.

2.6.1 SCPI overview

IEEE-488.2 defines a syntax and protocol for sending data to and from instruments. It also defines a set of common commands that are used to perform basic operations, such as reading status registers, providing triggers, and resetting the instrument to default conditions.

SCPI (Standard Commands for Programmable Instruments) defines a standard set of commands (and format) to control every aspect of instrument operation. Together, IEEE-488.2 and SCPI create a command structure for all programmable instruments.

2.6.2 Compatibility

An instrument that uses the IEEE-488.2 standard and SCPI does not have any special hardware requirements. The IEEE-488 interface that you used with the old standard (IEEE-488.1) will work with the new standard. Simply connect the Model 2001 to a computer that is equipped with an IEEE-488 interface.

NOTE

The term GPIB (General Purpose Interface Bus) is used in this manual and in the menu structure of the instrument. GPIB is simply another term for the IEEE-488 bus.

2.6.3 Bus connection

Before using the instrument over the bus, you must connect the IEEE-488 connector on the rear panel of the instrument to the IEEE-488 connector of your controller. Use a Keithley Model 7007 or similar IEEE-488 cable for this connection.

2.6.4 Primary address

The primary address of the Model 2001 must agree with the primary address you intend to specify in the controller's programming language. The factory setting for the primary address is 16, so if you intend to use that address, you need not change it. However, the primary address can be set to any value between 0 and 30 by using the GPIB setup menu (ADDRESSABLE selection) available with the MENU key.

2.6.5 Abbreviated common command summary

Table 2-6 provides an abbreviated list of common commands that are defined by the IEEE-488.2 standard. These are the common commands that are most used for bus operation. Note that each common command is preceded by an asterisk (*).

2.6.6 Abbreviated SCPI command summary

Most instrument operations are controlled using SCPI commands. Table 2-7 provides an abbreviated list of the SCPI commands necessary to perform some basic operations.

Not shown in the table are companion query commands for the :ARM and :TRIGger subsystem commands (:COUNt?, :DELay?, :SOURce?, and :TIMer?). For example, the :TRIGger:SOURce? query command is used to request the presently selected control source. After the query command is sent and the Model 2001 is addressed to talk, a message identifying the selected control source will be sent to the computer.

Table 2-6
Abbreviated common command summary

Mnemonic	Name	Description
*CLS	Clear status	Clears error queue, event registers, and IEEE-488 bus service request (SRQ) line.
*RCL <n>	Recall	Returns the instrument to the setup configuration stored in memory (n = 0 for STD, n = 0 to 4 for MEM1, or n = 0 to 9 for MEM2).
*RST	Reset	Returns the Model 2001 to *RST default conditions (see Appendix B).
*SAV <n>	Save	Saves the present setup configuration in memory (n = 0 for STD, n = 0 to 4 for MEM1, or n = 0 to 9 for MEM2).
*TRG	Trigger	Issues a bus trigger (same as group execute trigger command; GET).

Table 2-7
Abbreviated SCPI command summary

Command	Description
:SYSTem	Subsystem command path.
:PRESet	Set unit to a default configuration (see Appendix B).
[:SENSe[1]]	Subsystem command path.
:VOLTage[:DC]	Path to configure DC voltage.
:APERture <n>	Specify integration time in seconds (n = 166.67e-6 to 200e-3).
:AVERage	Path to control averaging filter:
:COUNt <n>	Specify number of points to average (n = 1 to 100).
:STATe ON|OFF	Enable/disable averaging filter.
:NPLCycles <n>	Specify integration time in number of line cycles (n = 0.01 to 10).
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (n = -1100 to +1100).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) autorange.
:REFerence <n>	Specify REL value (n = -1100 to +1100).
:RESolution <n>	Specify measurement resolution (number of digits; n = 4 to 8).
:INITiate	Initiate one trigger (measure) cycle.
:ABORt	Reset trigger system and go to idle state.
:ARM	Subsystem command path to configure scan:
:LAYer2	Path to program scan layer:
:COUNt <n>|INF	Program number of scans (1 to 99999 or INFinite).
:DELay <num>	Program delay (0 to 999999.999sec).
:SOURce HOLD|IMMediate| TIMer| MANual|BUS|TLINk| EXTernal	Select event to control scan trigger.
:TIMer <num>	Set timer interval (0.001 to 999999.999sec).
:TRIGger	Subsystem command path to program measure layer:
:COUNt <n>|INF	Program number of measurements (1 to 99999, or INFinite).
:DELay <num>	Program delay (0 to 999999.999sec).
:SOURce HOLD|IMMediate|MANual| BUS| TLINK| EXTernal|TIMer	Select event to control measure trigger.
:TIMer <num>	Set timer interval (0.001 to 999999.999sec).
:ROUTe	Subsystem command path for scanning.
:CLOSe <list>	Path and command to close channel.
:STATe?	Request closed status of channel list.
:OPEN <list>|ALL	Open specified channels.
:SCAN <list>	Path and command to specify internal list.
:EXTernal <list>	Command to specify external list.

Notes:
1. Command short form is indicated by the uppercase characters. For example, instead of sending ":arm:layer2:source immediate", you can send ":arm:lay2:sour imm".
2. The brackets [ ] indicate optional names that need not be sent. For example: [:SENSe[1]]:VOLTage:DC:RANGe:[UPPer] 5 is the same as :VOLTage:DC:RANGe 5.

2.6.7 Syntax rules

The following information explains some of the programming syntax for the Model 2001. For more complete information, see Programming Syntax, which is located just after the tab labeled "SCPI Command Subsystems".

General form

The general form for SCPI commands is demonstrated in Table 2-7. Notice that they are hierarchical in nature and begin with a root command. For example, to set autoranging on the DC voltage function, you would send the following command:

```
:VOLT:DC:RANG:AUTO  ON
```

The root command for the above example is [:SENSe[1]]. This is an optional command word (as indicated by the brackets in the table) and need not be used.

Note that there must be a space between the command word and the parameter. In the above example, there is a space between the :AUTO command word and the ON parameter.

SCPI command words and common commands are not case sensitive. They can be sent in uppercase or lowercase. The commands in Table 2-7 show a combination of upper and lowercase characters. The uppercase characters identify the short-form version of the command. For example, all the following versions of the same program message are valid:

```
:ARM:LAYER2:SOURCE  MANUAL
:ARM:LAY2:SOURCE  MAN
:ARM:LAY2:SOUR  MAN
:arm:layer2:source  manual
:arm:lay2:sour  man
:Arm:Lay2:Sour  Man
:ArM:LaY2:SouR MaN
```

Parameters

As previously mentioned, a parameter is separated from the command word by a space character. The parameter can consist of one or more data types, such as integer, real, Boolean, string, name, or list. Some examples follow:

1. :voltage:dc:resolution 4
2. :trigger:delay 0.5
3. :display:window2:text:state on
4. :display:window2:text:data 'Model 2001'
5. :voltage:dc:average:tcontrol moving
6. :route:scan:internal (@1:3,5)

1. 4 — This integer parameter sets the DC voltage resolution to 3.5 digits.
2. 0.5 — This real number parameter sets the trigger delay period in seconds.
3. ON — This Boolean parameter enables the display of user text messages on the display, in this case, the bottom line. A "1" could have been used instead. "OFF" or "0" disables the function.
4. Model 2001 — This string parameter specifies the user text message. Single or double quotes delimit the message. Note that the previous command must be sent to enable the display of user text messages.
5. MOVing — This name parameter specifies the mode of the averaging or advanced digital filter.
6. (@1:3,5) — This list parameter specifies an internal scan list for the Model 2001-SCAN. Parentheses are used to enclose the list of channels. The @ symbol must precede the first channel in the list. A colon is used as a separator for the range limits (channels 1 through 3). Each channel or channel range in the list must be separated by a comma.

Multiple commands

Multiple commands can be sent in the same message as long as they are separated by semicolons. For example:

Instead of sending ...
```
:system:error?
:system:preset
```

You can send ...
```
:system:error?;preset
```

When the above message is sent, the first command word is recognized as the root command. When the command parser sees a colon after a semicolon, it resets the path pointer to the root before processing the next command.

Proper use of the path pointer allows commands in the same command level to be serviced without having to retype the entire command path. For example, the command :ARM:LAYer2:SOURce MANual moves the path pointer down to the last command level in the path. As a result, the :count, :delay, and :timer commands and their companion query commands can be included in the same program message without repeating the entire path. Some examples follow:

Instead of sending ...
```
:arm:lay2:sour  man;:arm:lay2:sour?
```

You can send ...
```
:arm:lay2:sour  man;sour?
```

Instead of sending ...
:trig:coun 1;:trig:del 1;:trig:tim 1

You can send ...
:trig:coun 1;del 1;tim 1

Notice that the colon for the additional commands is not included. Remember, when a colon (not preceded by a semicolon) is seen, the path pointer moves down to the next command level. For example:

:trig:del 1;tcon:prot asyn

When this message is sent, the path pointer moves down one command level for the DELAY and TCONFIGURE commands. The colon after the TCONFIGURE command then moves the pointer down to the next command level and enables PROTOCOL.

A few important points:

1. The path pointer can only move down. It cannot be moved up a level. (Note: It can be reset to the root mode by a preceding colon. For example, :ARM:LAY2: SOUR MAN; :TRIG:SOUR MAN.)
2. Each new message (line) must begin with the root command.
3. The colon at the beginning of a program message is optional.
4. The end of a program message moves the path pointer back to the root; so does a leading colon.
5. Any time one or more query commands are included in a program message, the Model 2001 must be addressed to talk to send the response message to the computer.

2.6.8 Programming examples

The following programming examples are written in the Hewlett-Packard BASIC 4.0 programming language. The programs assume that the Model 2001 is set to primary address 16.

Programming example #1 — Default DC voltage reading

The following code fragment resets the Model 2001 to a default configuration and gets a DC voltage reading:

```
100  OUTPUT 716;":syst:pres"
110  OUTPUT 716;":fetch?"
120  ENTER 716;A$
130  PRINT A$
```

Line 100 Return Model 2001 to :SYSTem:PRESet default configuration (DC volts, autorange, 1 PLC, filter enabled, 6.5 digits).
Line 110 Request new reading.
Line 120 Address to talk.
Line 130 Display reading, status, units, time-stamp, reading number, and channel.

Programming example #2 — High accuracy DC voltage reading

The following code fragment configures the Model 2001 for high accuracy DC voltage readings and gets one reading:

```
100  OUTPUT 716;":syst:pres"
110  OUTPUT 716;":volt:dc:nplc  10"
120  OUTPUT 716;":fetch?"
130  ENTER 716;A$
140  PRINT A$
```

Line 100 Return Model 2001 to default configuration.
Line 110 Change integration time to 10 PLC (and resolution to 7.5d).
Line 120 Request new reading.
Line 130 Address to talk.
Line 140 Display reading status, units, time-stamp, reading number, and channel.

Programming example #3 — High speed DC voltage readings

The following code fragment configures the Model 2001 for high speed DC voltage readings, stores 100 readings, and sends the readings over the bus:

```
100  OUTPUT 716;":syst:pres"
110  OUTPUT 716;":volt:dc:nplc  0.01"
120  OUTPUT 716;":trac:clear"
130  OUTPUT 716;":trac:feed  calc"
140  OUTPUT 716;":trac:egr  full"
150  OUTPUT 716;":trac:poin  100"
160  OUTPUT 716;":trac:feed:cont  next"
170  OUTPUT 716;":trac:data?"
180  ENTER 716;A$
190  PRINT A$
```

Line 100 Return Model 2001 to default configuration.
Line 110 Change integration time to 0.01 PLC.
Line 120 Clear all stored readings.
Line 130 Perform any math before storing readings.
Line 140 Store full data group (reading, reading number, units, timestamp, status, and channel).
Line 150 Set buffer count to 100 readings.
Line 160 Start storing, stop when done.

Line 170 Request readings (default is reading only, ASCII format).
Line 180 Address to talk.
Line 190 Display readings, status, units, time-stamps, reading numbers, and channels.

Programming example #4 — Burst speed DC voltage readings

The following code fragment configures the Model 2001 for burst speed DC voltage readings, stores 100 readings, and sends the readings over the bus:

```
100  OUTPUT 716;":syst:pres"
110  OUTPUT 716;":syst:amet  burs"
120  OUTPUT  716;  "form:elem  read,  rnum,  unit,
stat"
130  OUTPUT 716;":trac:clear"
140  OUTPUT 716;":trac:feed  calc"
150  OUTPUT 716;":trac:poin  100"
160  OUTPUT 716;":init"
170  WAIT 2
180  OUTPUT 716;":trac:data?"
190  ENTER 716;A$
200  PRINT A$
```

Line 100 Return Model 2001 to default configuration.
Line 110 Change acquisition method to burst; put unit in idle.
Line 120 Specify data elements (reading, reading number, units, and status).
Line 130 Clear all stored readings.
Line 140 Perform any math before storing readings.
Line 150 Set buffer count to 10 readings.
Line 160 Take unit out of idle; perform reading burst; return to idle.
Line 170 Wait for burst to complete.
Line 180 Request readings (default is readings only, ASCII format).
Line 190 Address to talk.
Line 200 Display readings.

3

Front Panel Operation

3.1 Introduction

This section contains detailed information on front panel operation of the Model 2001. It is organized as follows:

3.2 **Power-up procedure:** Covers information on connecting the instrument to line power, warm-up period, default conditions, and the power-up sequence.

3.3 **Display:** Covers display format and messages that may appear while using the instrument.

3.4 **Functions:** Describes the measurement functions of the instrument (DC and AC voltage, DC and AC current, 2-wire and 4-wire resistance, frequency, and temperature) and typical test connections.

3.5 **Range:** Covers both manual and autoranging operation.

3.6 **Relative:** Gives details on using the relative feature that can be used to null offsets or subtract a baseline value from present and future readings.

3.7 **Triggering:** Details types of trigger modes as well as trigger sources that can be used.

3.8 **Buffer:** Covers use of the reading buffer including programming buffer size and recalling data, time stamp, and statistics information.

3.9 **Filter:** Covers the use of the digital filter types that can be used to reduce reading noise.

3.10 **Math:** Describes the calculations that can be performed on readings in continuous operation.

3.11 **Scanning:** Discusses setting up internal and external scans, along with ratio and delta calculations.

3.12 **Menu:** Covers selections controlled from the main menu, such as saving instrument setups, GPIB (IEEE-488 bus) configuration, calibration, self-tests, limits, and the digital I/O port.

3.2 Power-up procedure

3.2.1 Line power connections

Follow the procedure below to connect the Model 2001 to line power and turn on the instrument.

1. The Model 2001 operates from a line voltage in the range of 90-134V or 180-250V at a frequency of 50, 60, or 400Hz. Check to see that the operating voltage in your area is compatible.

CAUTION

Operating the instrument on an incorrect line voltage may cause damage to the instrument, possibly voiding the warranty.

2. Before plugging in the power cord, make sure the front panel power switch is in the off (0) position.
3. Connect the female end of the supplied power cord to the AC receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

WARNING

The power cord supplied with the Model 2001 contains a separate ground wire for use with grounded outlets. When

proper connections are made, instrument chassis is connected to power line ground through the ground wire in the power cord. Failure to use a grounded outlet may result in personal injury or death due to electric shock.

3.2.2 Line fuse replacement

A rear panel fuse located below the AC receptacle protects the power line input of the instrument. If the fuse needs to be replaced, perform the following steps:

WARNING

Make sure the instrument is disconnected from the power line and other equipment before replacing the line fuse.

1. With the power off, place the end of a flat-blade screwdriver into the rear panel LINE FUSE holder. Push in gently and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure on the holder and its internal spring will push the fuse carrier out of the holder.
2. Remove the fuse and replace it with the same type (0.5A, 250V, slow blow, 5 × 20mm). The Keithley part number is FU-71.

CAUTION

Do not use a fuse with a higher current rating than specified, or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse. See the optional Model 2001 Repair Manual for troubleshooting information.

3. Install the new fuse and fuse carrier into the holder by reversing the above procedure.

3.2.3 Power-up sequence

To turn on the power, simply push in the front panel POWER switch. Power is on when the switch is in the inner (1) position. To turn off power, press POWER a second time to release the switch.

On power-up, the Model 2001 performs self-tests on its EPROM and RAM, and checksum tests on data stored in non-volatile memory. (See Table 3-1.) If a failure is detected, the instrument momentarily displays an error message and the ERR annunciator turns on. (Messages are listed in Table 3-2.)

NOTE

If a problem develops while the instrument is under warranty, return it to Keithley Instruments, Inc. for repair. (See paragraph 1.3.)

If the instrument passes the self-tests, the firmware revision levels, memory option (if installed), and presently selected IEEE-488 primary address are displayed. An example of this display is shown as follows:

Model 2001
Rev. A01 A01 MEM1 IEEE Addr=16

The firmware revision levels (left to right) are for the main microcontroller and display microcontroller. The revision level number may be different in your particular unit. If the MEM1 or MEM2 memory options are not present, that portion of the bottom line is left blank. The IEEE-488 address is its default value of 16.

Next, if the unit is configured to display the calibration due date at power-up, the unit shows the following:

Model 2001
Calibration due: mmm/dd/yy

where "mmm" is the month abbreviation, "dd" is the day, and "yy" is the year. If no calibration date is set, the display shows that it is due now. (See the Model 2001 Calibration Manual to set the calibration due date and paragraph 3.12.3 of this manual to set the display option.)

After the power-up sequence, the instrument begins its normal display, for example:

000.0000 mVDC

Power-up error messages

Error messages that may be displayed during power-up are summarized in Table 3-2. These are shown when one of the checksum tests of Table 3-1 fails.

Table 3-1
Data checked on power-up

Data	Type of storage	Memory option
IEEE-488 address	Electrically-erasable PROM	STD, MEM1, MEM2
Power-on default	Electrically-erasable PROM	STD, MEM1, MEM2
Calibration constants	Electrically-erasable PROM	STD, MEM1, MEM2
Calibration dates	Electrically-erasable PROM	STD, MEM1, MEM2
Instrument setups	1 in electrically-erasable PROM	STD, MEM1, MEM2
	4 more in non-volatile RAM	MEM1
	9 more in non-volatile RAM	MEM2
Reading buffer	(Volatile RAM)	STD
	Non-volatile RAM	MEM1, MEM2

Note: STD is standard memory, MEM1 is memory option #1, MEM2 is memory option #2.

Table 3-2
Power-up error messages

Message	Action
Error +515, Calibration dates lost	The cal dates are set to factory default values, but they are not stored into EEPROM. To do this, perform a comprehensive calibration.
Error +514, DC calibration data lost	DC cal constants are set to factory default values, but they are not stored into EEPROM. To do this, perform a comprehensive calibration.
Error +513, AC calibration data lost	AC cal constants are set to factory default values, but they are not stored into EEPROM. To do this, perform a comprehensive calibration.
Error +512, Power-on state lost	Power-on defaults are reset to factory defaults (bench) and stored into EEPROM.
Error +511, GPIB address lost	GPIB address is reset to factory default (16) and stored into EEPROM.
Error +510, Reading buffer data lost	The reading buffer controls are reset to factory defaults, but they are not stored into NVRAM. To do this, store readings in the buffer.
Error -314, Save/recall memory lost	Instrument setup is reset to bench defaults and stored into EEPROM.

Notes:
1. Any of these error conditions may occur the first time a unit is turned on or after replacing the firmware.
2. Error +510, Reading buffer data lost, applies to units with optional memory.
3. Error +512, Power-on state lost, may occur the first time the unit is powered-up after replacing the MEM2 memory option with MEM1.

3.2.4 High energy circuit safety precautions

To optimize safety when measuring voltage in high energy distribution circuits, read and use the directions in the following warning.

WARNING

Dangerous arcs of an explosive nature in a high energy circuit can cause severe personal injury, or death. If the multimeter is connected to a high energy circuit when set to a current range, low resistance range, or any other low impedance range, the circuit is virtually shorted. Dangerous arcing can result even when the multimeter is set to a voltage range if the minimum voltage spacing is reduced.

When making measurements in high energy circuits, use test leads that meet the following requirements:

- Test leads should be fully insulated.
- Only use test leads that can be connected to the circuit (e.g., alligator clips, spade lugs, etc.) for hands-off measurements.
- Do not use test leads that decrease voltage spacing. This diminishes arc protection and creates a hazardous condition.

Use the following sequence when testing power circuits:

1. De-energize the circuit using the regular installed connect-disconnect device, such as a circuit breaker, main switch, etc.
2. Attach the test leads to the circuit under test. Use appropriate safety rated test leads for this application.
3. Set the multimeter to the proper function and range.
4. Energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the multimeter.
5. De-energize the circuit using the installed connect-disconnect device.
6. Disconnect the test leads from the circuit under test.

WARNING

The maximum common-mode voltage (voltage between INPUT LO and chassis ground) is 500V peak. Exceeding this value may cause a breakdown in insulation, creating a shock hazard.

3.2.5 Power-on default conditions

Power-on default conditions are those conditions the instrument assumes when it is first turned on. You can change these power-on default conditions (except the primary address) by using the save setup feature that is available with the MENU key, as described in paragraph 3.12.1. Depending on the installed memory option, either one, five, or ten user-defined setups can be stored, any one of which could be selected as the power-on default.

A table in paragraph 3.12.1 lists the default conditions that are set at the factory to optimize bench and GPIB (IEEE-488) operation.

3.2.6 Warm-up period

The Model 2001 can be used within one minute after it is turned on. However, the instrument should be turned on and allowed to warm up for at least one hour before use to achieve rated accuracy.

3.2.7 IEEE-488 primary address

The IEEE-488 primary address of the instrument must be the same as the primary address you specify in the controller's programming language. The default primary address of the instrument is 16, but you can set the address to any value from 0 to 30 by using the MENU key. Refer to paragraph 3.12.2 for step-by-step instructions on setting the primary address. Section 4 contains details on using the Model 2001 over the IEEE-488 bus.

3.3 Display

The display of the Model 2001 is primarily used to display readings along with the units and type of measurement. When not displaying readings, it is used for informational messages, such as menu headings and selections. At the top of the display are annunciators to indicate various states of operation.

3.3.1 Display format

As shown in Figure 3-1, the front panel has two lines of display information:

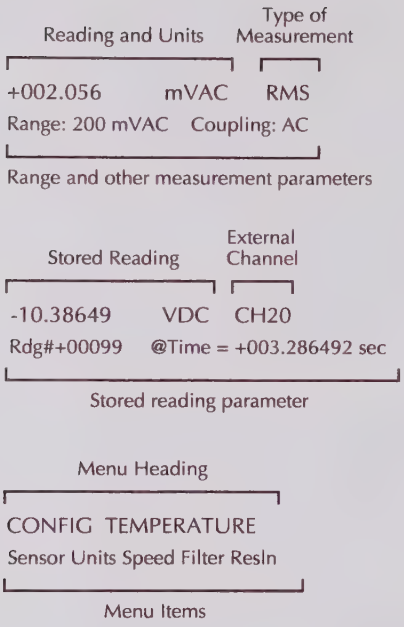


Figure 3-1
Model 2001 display formats

- The top line can display readings up to 7½ digits, along with units. It can also indicate the measurement type (e.g., RMS), display "hold", type of math operation, channel number, or limits pass/fail. It is also used for menu headings, values of stored readings, and messages.
- The bottom line displays the range and other measurement parameters (e.g., coupling or ratio), multiple displays, menu items, parameters of stored readings, and messages. For longer text strings, the bottom line is split in half. These are indicated by ◄ and ► characters at the left or right end of the bottom line. Press the cursor keys (◄ and ►) to view each half.

Scientific notation

Enabling a relative or math operation might cause the reading value to exceed the display resolution of the top line. In these cases, the instrument displays in 7½ digits of scientific notation. If the units have a multiplier prefix (milli-, micro-, etc.), the exponent of the value reflects that. Note that ratio measurements are always shown in 7½ digit scientific notation with no prefix or channel number.

The actual value of the reading, before the relative or math operation, can be viewed on the bottom line with the appropriate multiple display. (See Figure 3-2). The units and multiplier prefix on the bottom line are assumed to be the same as those on the top line reading.

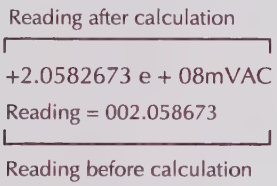


Figure 3-2
Scientific notation with calculate multiple display

Annunciators

The annunciators at the top of the display indicate the following conditions:

ERR: The displayed reading is questionable. See paragraph 4.21 for the conditions that define a questionable reading.

REM: Indicates the Model 2001 is in remote when used over the IEEE-488 bus. The Model 2001 can be placed in remote by addressing it to listen with the bus REN line true.

TALK: Shows that the Model 2001 is the active talker on the IEEE-488 bus. The unit can be placed in the talker active state by sending it the correct bus talk command, which is derived from the primary address.

LSTN: Turns on when the unit is an active IEEE-488 bus listener. The Model 2001 can be placed in the active listener state by addressing it to listen.

SRQ: Turns on when the unit requests service over the IEEE-488 bus. The SCPI STATus command allows you to control which conditions generate an SRQ (see paragraph 4.21).

REAR: Turns on when a reading has been acquired through the rear inputs.

REL: Turns on/off to indicate the present state of the relative reading feature.

FILT: When filtering has been selected for a particular function, this indicator turns on when the FILTER key is pressed. For those functions with auto-filtering, it turns on when AUTO is selected.

MATH: When a math operation (percent, mX+b, or none) has been selected from the CONFIGURE MATH menu, this indicator turns on when the MATH key is pressed.

4W: Turns on to indicate the 4-wire resistance function, in-circuit current, or temperature with a 4-wire RTD.

AUTO: Turns on when autoranging is selected for voltage, current (except in-circuit current, which has a fixed 12A range), or resistance measurements.

ARM: Turns on when the Model 2001 is taken out of the idle state (by the TRIG key or the :INIT or :INIT:CONT ON bus command). A measurement can only be performed with the Model 2001 out of the idle state.

*: Indicates when normal readings are being stored.

3.3.2 Multiple displays

Each measurement function has its own set of "multiple displays" shown on the bottom line of the front panel display. The PREVious and NEXT DISPLAY keys scroll through the selections for the present function.

Some of the multiple displays are for multiple functions, where different functions are measured sequentially from the same set of test leads. The readings are shown simultaneously, such as:

- Top line shows a DC voltage measurement; bottom line shows positive and negative peak spike measurements.
- Top line shows an AC RMS voltage reading; bottom line shows an AC frequency measurement and a crest factor calculation.

Also, the multiple displays can show a reading in a different form, or give additional information about the reading, for example:

- Top line shows a reading; bottom line shows a zero-centered bar graph with adjustable limits.
- Top line shows a frequency measurement; bottom line shows the adjustable trigger level.

To scroll through the multiple displays available for each measurement function, repeatedly press and release the NEXT DISPLAY key. The same action with the PREVious DISPLAY key does a reverse scroll through the displays. To return to the default reading display, just press and hold either key.

Multiple displays that are specific to a particular function or operation are discussed later in this section, such as the peak spikes displays in DC voltage, and the calculations display in math. (See Table 3-3 for paragraph references.) Displays that are common to most of the measurement functions are discussed here. Appendix H shows a complete listing of the multiple displays by function.

Table 3-3
Multiple displays by function

Function	Next display	Paragraph
All	Bar graph	3.3.2
	Zero-centered bar graph	3.3.2
	Maximum and minimum values	3.3.2
	Relative and actual values	3.6
	Calculated and actual values (see Note 1)	3.10
	Limits bar graph (see Note 1)	3.12.5
	Adjacent channel readings (see Note 2)	3.11
DC voltage	DC volts, AC ripple voltage and frequency	3.4.1
	Positive peak spikes and highest value	
	Negative peak spikes and lowest value	
	Positive and negative peak spikes	
AC voltage	AC RMS voltage, frequency, and crest factor	3.4.1
	AC RMS, average, and peak voltages	
DC current	(none specific to function)	3.4.2
AC current	AC RMS (or average) current and frequency	3.4.2
	AC RMS and average current	
2-wire resistance	Source current	3.4.3
	Voltage drop across DUT	
4-wire resistance	Source current	3.4.3
	Voltage drop across DUT	
	Lead resistance	
Frequency	Period calculation	3.4.4
	Trigger level	
Temperature	Celsius, Fahrenheit, and Kelvin units	3.4.5
	RTD resistance (or thermocouple voltage)	
	Reference junction (thermocouples only)	
Data storage buffer	Maximum and minimum values	3.8
	Average and standard deviation	

Notes:
1. Multiple displays for calculated values and limits bar graph are not available for the frequency function.
2. The multiple display for adjacent channel readings is not available for the DC and AC current functions.

Bar graph

The "normal" bar graph, with a zero at the left end, is a graphical representation of a reading as a portion of a range. (See Figure 3-3.) The vertical lines displayed along the bar designate 0%, 25%, 50%, 75%, and 100% of full scale. Each full segment of the bar represents approximately 4% of the range limit

.

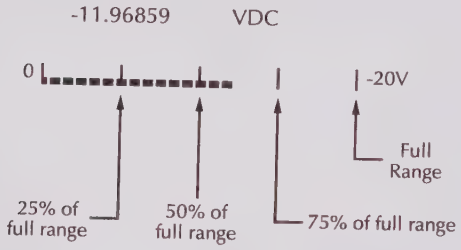


Figure 3-3
Bar graph (zero-at-left) multiple display

For measurement functions with a range (voltage, current, and resistance), the right endpoint of the bar graph is plus full scale of the present range for positive readings, and minus full scale for negative readings. When the 100% line changes to an arrow, the reading exceeds the present range.

Note that the normal bar graph is not available when the ACV units are dB or dBm.

For functions without a range (frequency and temperature), the right endpoint of the bar graph is user-programmable by pressing either CONFIG-NEXT DISPLAY or CONFIG-PREV DISPLAY. Note that these configuration menus are context-sensitive. If the unit is in any function except frequency or temperature, CONFIG-NEXT DISPLAY results in the zero bar graph configuration display.

Perform the following to view or change the range of the bar graph:

1. From the frequency or temperature function, press the CONFIG key and then the NEXT or PREV DISPLAY key. The following menu is displayed:

   BARGRAPH TYPE
   ZERO-AT-LEFT ZERO-CENTERED

2. Use the cursor keys (◄ and ►) to place the cursor on ZERO-AT-LEFT and press ENTER. You will access one of the following menus:

   For frequency:

   FREQ BARGRAPH RANGE
   2Hz 20Hz 200Hz 2kHz 20kHz ►
   ◄ 200kHz 2MHz 15MHz

   For temperature:

   BARGRAPH:0 to 0040°C

3. Change the frequency range by highlighting one of the selections and pressing ENTER. For the temperature range, use the cursor keys and the RANGE ▲ and ▼ keys to enter a numeric value (0 - 9999°C). Press ENTER when done.

Zero-centered bar graph

The zero-centered bar graph is a graphical representation of a reading with plus and minus limits. (See Figure 3-4.) The limits are expressed in a user-selectable percentage of range for voltage, current, and resistance, and a user-selectable value for frequency and temperature.

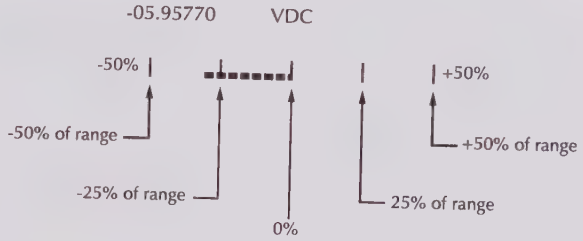


Figure 3-4
Zero-centered bar graph multiple display

The vertical lines displayed along the bar designate the plus and minus limits, zero, and halfway to either limit. There are ten full segments between zero and each end, so each full segment represents 10% of the limit. When a line at the limit changes to an arrow, the reading exceeds the programmed range.

The plus and minus percentage of range that is programmed (0.01 - 99.99%) applies to all voltage, current, and resistance functions. Because of rounding, values greater than 99.5% are shown as 100% and, likewise, values greater than 1% (such as 1.67%) are shown rounded to the nearest integer percent.

Note that the zero-centered bar graph is not available when the ACV units are dB or dBm.

Perform the following to view or change the plus and minus percentage of range:

1. From a voltage, current, or resistance function, press CONFIG and then NEXT or PREV DISPLAY. The following is displayed:

   ZERO-BARGRAPH±50.00%

2. Change the percentage by using the cursor keys and the RANGE ▲ and ▼ keys to enter a numeric value (0.01 - 99.99%). Press ENTER when done. The same percentage of range is used for voltage, current, and resistance measurements.

Perform the following to view or change the plus and minus value limit:

1. From the frequency or temperature function, press CONFIG and then NEXT or PREV DISPLAY. The following menu is displayed:

   BARGRAPH TYPE
   ZERO-AT-LEFT ZERO-CENTERED

2. Use the cursor keys (◄ and ►) to place the cursor on ZERO-CENTERED and press ENTER. You will access one of the following menus:

   For frequency:

   FREQ ZEROBARGRAPH(±)
   1Hz 10Hz 100Hz 1kHz 10kHz ►
   ◄ 100kHz 1MHz 10MHz 15MHz

   For temperature:

   ZERO-BARGRAPH±0002°C

3. Change the frequency limits by highlighting one of the selections and pressing ENTER. For the temperature, use the cursor keys and the RANGE ▲ and ▼ keys to enter a numeric value (0 - 9999°C). Press ENTER when done.

Maximum and minimum

The maximum and minimum multiple display shows the maximum and minimum readings since the display was entered. (See Figure 3-5.) The maximum and minimum values are reset by the following:

- Pressing the present function key.
- Leaving the display by changing function or entering a menu.

Figure 3-5
Maximum and minimum multiple display

The resolution, units, and prefix on the bottom line are the same as shown for top line reading. If necessary, the bottom line values automatically change to scientific notation, rounded to 4.5 digits.

3.3.3 Information messages

Press the INFO key to view context-sensitive information from most of the displays. An arrow (◄ or ►) on the bottom line indicates that there is more information. Use the cursor keys (◄ and ►) to view the complete line. To exit an INFO display, just press INFO, ENTER, EXIT, or a function key.

Information messages are included with the listing of menu structures in Appendix H.

3.3.4 Status and error messages

During Model 2001 operation and programming, you will encounter a number of front panel messages. Typical messages are either of status or error variety, as listed in Table 3-4.

For firmware revisions A02 and greater, the most recent status or error messages can be momentarily displayed. Just enter a configuration menu or the main menu, and press the AUTO range key. (The display is blank if no message is queued.)

Table 3-4
Status and error messages

Number	Description	Event
+900	"Internal System Error"	EE
+611	"Questionable Temperature"	SE
+610	"Questionable Calibration"	SE
+515	"Calibration dates lost"	EE
+514	"DC calibration data lost"	EE
+513	"AC calibration data lost"	EE
+512	"Power-on state lost"	EE
+511	"GPIB address lost"	EE
+510	"Reading buffer data lost"	EE
+444 to +350	Calibration Errors (see Calibration Manual)	EE
+312	"Buffer Pretriggered"	SE
+310	"Buffer full"	SE
+309	"Buffer half full"	SE
+308	"Buffer Available"	SE
+306	"Reading Available"	SE
+305	"High limit 2 event"	SE
+304	"Low limit 2 event"	SE
+303	"High limit 1 event"	SE
+302	"Low limit 1 event"	SE
+301	"Reading overflow"	SE
+174	"Re-entering the idle layer"	SE
+173	"Waiting in arm layer 2"	SE
+172	"Waiting in arm layer 1"	SE
+171	"Waiting in trigger layer"	SE
+161	"Program running"	SE
+126	"Device calculating"	SE
+125	"Device measuring"	SE
+124	"Device sweeping"	SE
+123	"Device ranging"	SE
+122	"Device settling"	SE
+121	"Device calibrating"	SE
+101	"Operation Complete"	SE
+000	"No Error"	SE
-100	"Command Error"	EE
-101	"Invalid Character"	EE
-102	"Syntax Error"	EE
-103	"Invalid Separator"	EE
-104	"Data Type Error"	EE
-105	"GET not allowed"	EE
-108	"Parameter not allowed"	EE
-109	"Missing Parameter"	EE
-110	"Command Header Error"	EE
-111	"Command Header Separator Error"	EE
-112	"Program mnemonic too long"	EE
-113	"Undefined header"	EE
-114	"Header suffix out of range"	EE

Table 3-4 (Continued)
Status and error messages

Number	Description	Event
-120	"Numeric data error"	EE
-121	"Invalid character in number"	EE
-123	"Exponent too large"	EE
-124	"Too many digits in number"	EE
-128	"Numeric data not allowed"	EE
-140	"Character data error"	EE
-141	"Invalid character data"	EE
-144	"Character data too long"	EE
-148	"Character data not allowed"	EE
-150	"String data error"	EE
-151	"Invalid string data"	EE
-154	"String too long"	EE
-158	"String data not allowed"	EE
-160	"Block data error"	EE
-161	"Invalid block data"	EE
-168	"Block data not allowed"	EE
-170	"Expression error"	EE
-171	"Invalid expression"	EE
-178	"Expression data not allowed"	EE
-200	"Execution error"	EE
-201	"Invalid while in local"	EE
-202	"Settings lost due to rtl" (return to local)	EE
-210	"Trigger error"	EE
-211	"Trigger ignored"	EE
-212	"Arm ignored"	EE
-213	"Init ignored"	EE
-214	"Trigger deadlock"	EE
-215	"Arm deadlock"	EE
-220	"Parameter Error"	EE
-221	"Settings conflict"	EE
-222	"Parameter data out of range"	EE
-223	"Too much data"	EE
-224	"Illegal parameter value"	EE
-230	"Data corrupt or stale"	EE
-241	"Hardware missing"	EE
-260	"Expression Error"	EE
-314	"Save/recall memory lost"	EE
-330	"Self Test failed"	EE
-350	"Queue overflow"	EE
-410	"Query interrupted"	EE
-420	"Query unterminated"	EE
-430	"Query deadlocked"	EE
-440	"Query unterminated after indefinite response"	EE

SE = Status event
EE = Error event

3.3.5 Menu structures

From the front panel of the Model 2001, you configure measurements through the use of menus. A complete listing of the menus is given in Appendix H. The menus are grouped into three areas:

- Measurement functions: DC voltage, AC voltage, DC current, AC current, 2-wire resistance, 4-wire resistance, frequency, and temperature.
- Measurement operations: Multiple displays, relative readings, triggers, reading storage, digital filter, math, channels, and scanning.
- Other menu operations: Setup storage, IEEE-488 (GPIB) setup, calibration, self-tests, limits, status messages, and general operations.

The first two groups have specific keys on the front panel. The third group does not. The desired menu is displayed by pressing the appropriate key or key sequence:

- CONFIG and then DCV (or ACV, DCI, ACI, Ω2, Ω4, FREQ, TEMP): Shows the configuration menu for each measurement function.
- CONFIG and then NEXT DISPLAY (or PREV DISPLAY, REL, TRIG, STORE, FILTER, MATH, CHAN, SCAN): Shows the configuration menu for the multiple displays and each measurement operation.
- MENU: The main menu accesses items for which there are no dedicated keys.

Navigating menus

1. From the instrument's normal state of displaying readings, you can:
   - View a configuration menu by pressing CONFIG and then the desired function or operation key (DCV, TRIG, etc.).
   - View the top level of the main menu by pressing the MENU key.
2. The unit is returned to the normal reading display by:
   - Pressing EXIT or MENU from the top level of the main menu.
   - Pressing EXIT from the top level of a configuration menu.
   - Pressing a measurement function key from within a menu.
3. Pressing the ENTER key selects an item and, if further definition is needed, moves down within the menu structure. Pressing the EXIT key backs up within a menu structure.
4. The cursor position is denoted by a blinking menu item or parameter. The cursor is moved from one item to the next using the cursor keys (◄ and ►). To select an item, highlight it with the cursor, then press ENTER.
5. A displayed arrow (◄ or ►) on the bottom line indicates there is more information or additional menu items to select from. When "►" is displayed, use the ► cursor key to display the additional message(s), and conversely, when "◄" is displayed, use the ◄ cursor key. The cursor keys have an auto-repeat feature.
6. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the RANGE ▲ or ▼ keys to increment or decrement the digit.
7. A change is only executed when the ENTER key is pressed. Entering an invalid parameter generates an error, and the entry is ignored. Changes are also ignored if an EXIT is performed.
8. The INFO key can be used anywhere in a menu to display helpful information messages concerning operation. To cancel an information message and remain in the menu, press INFO a second time, EXIT, or ENTER. Pressing a function key cancels INFO and a menu, and returns the instrument to a reading display.

3.3.6 EXIT key

The EXIT key has more actions than those mentioned in paragraph 3.3.5. Table 3-5 lists the action for single conditions.

When more than one of the conditions of Table 3-5 is present, the hierarchy for the action taken by each press of the EXIT key is as follows:

1. Cancels any temporary or error messages that are displayed.
2. Cancels INFO message and shows the normal reading display.
3. Cancels reading display hold and returns to normal reading display.
4. Disables scanning and returns to normal operation. Also interrupts data storage if enabled.
5. Interrupts data storage and returns to normal operation.

Table 3-5
EXIT key actions

Condition	EXIT key action
Temporary message displayed (e.g., TRIGGERS HALTED)	Cancels display of temporary message.
INFO message displayed	Cancels INFO message, returns to menu or normal reading display.
Reading display hold	Cancels reading display hold, resumes normal reading display.
Scanning	Disables scanning. Also stops data storage if enabled.
Data storage	Stops data storage. Temporary message STORAGE INTERRUPTED is displayed.

Some examples of when multiple conditions are cancelled by pressing the EXIT key follow.

Example 1: After pressing ENTER to hold the reading display, press INFO to view the message. The first press of EXIT returns you to the held reading; a second press cancels reading display hold.

Example 2: Configure a scan list and start scanning. Press ENTER to hold the display, then press INFO to view the message. The first press of EXIT returns you to the held reading; the second press returns you to the normal reading display. A third press of EXIT stops the scan and returns to normal operation.

Example 3: Configure a scan list and start scanning readings into a buffer. Press EXIT once. Scanning and storing are terminated; normal operation is resumed. Note that the trigger model is restored to its pre-scanning configuration.

Example 4: Configure a scan list and start scanning readings into a buffer. Press ENTER to hold the reading display. Press INFO to view the message. The first press of EXIT returns you to the held reading display. A second press of EXIT cancels the held reading and shows normal storage. A third press of EXIT stops scanning and storing; normal operation is resumed.

3.4 Functions

The Model 2001 has much flexibility when configuring the measurement functions. This flexibility must be used sensibly in order to balance the various settings for a particular application. For example, you can configure DC volts with an integration time of 0.01 PLC (power line cycle) at 7.5 digits of resolution and no filter, but the reading will be extremely noisy. As another example, DCV peak spikes can be configured for 7.5 digits of resolution, yet the measurement is specified at 3.5 digits. When in doubt, use the default settings and the auto selections until you become more familiar with the effects of other settings.

The instrument can be configured to display multiple functions, where different functions are measured sequentially from the same leads. These are referred to as "multiple displays" and they are shown on the bottom line of the display. The displays for multiple functions are discussed in the following paragraphs.

NOTE

All measurements in the multiple display mode will be within specifications. However, for optimum measurement integrity, the primary display mode should be used.

To minimize the need to reprogram setup conditions every time you switch from one function to another, each function "remembers" its own unique setup configuration. Setup configuration parameters that are remembered include:

- Range
- Relative
- Integration time
- Filtering
- Display resolution
- Multiple displays

To access the configuration menus for the measurement functions, press the CONFIG key and then a function key (DCV, ACV, DCI, ACI, Ω2, Ω4, FREQ, TEMP). Rules for navigating the menu structures are covered in paragraph 3.3.5.

3.4.1 DC and AC voltage

DC voltage measurements

The Model 2001 can make DC voltage measurements between 10nV and 1100V. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect the test leads to the INPUT HI and LO terminals of the Model 2001. Either the front or rear inputs can be used; place the INPUTS button in the appropriate position.
2. Select the DCV function.
3. Select a range consistent with the expected voltage. For automatic range selection, press the AUTO key. The AUTO annunciator denotes whether auto-ranging is enabled.
4. Connect the test leads to the source as shown in Figure 3-6.

CAUTION

Do not exceed 1100V peak between INPUT HI and LO, or instrument damage may occur.

5. Observe the display. If the "Overflow" message is shown, select a higher range until a normal reading is displayed. Always use the lowest possible range for the best resolution.
6. Take a reading from the display.

Zeroing

The term "when properly zeroed" means that you must establish a baseline for subsequent measurements on that range. The 200mV DC range requires zero to be set to achieve rated accuracy. This procedure should be performed whenever the ambient temperature changes. To zero (rel) the Model 2001, use the following procedure:

1. Disable rel, if presently enabled, by pressing the REL key. The REL annunciator will turn off.
2. Select the 200mVDC range.
3. Connect the test leads to INPUT HI and LO of the Model 2001 and short them together. Noise and thermal offsets may require a few moments to stabilize.
4. Press the REL key. The display will read zero.
5. Remove the short and connect the test leads to the signal to be measured.

Also, use shielded, low-thermal connections for the 200mV range to avoid errors caused by noise or thermal offsets. Connect the shield to the negative source terminal.

AC voltage measurements

The Model 2001 can make true RMS AC voltage measurements between 100nV and 775V. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect the test leads to the INPUT HI and LO terminals of the Model 2001.
2. Select the ACV function.
3. Select a range consistent with the expected voltage. For automatic range selection, press the AUTO key. The AUTO annunciator denotes whether autoranging is enabled.
4. Connect the test leads to the source as shown in Figure 3-7.

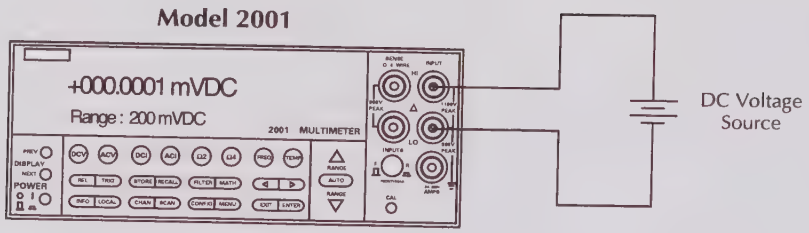
CAUTION

Do not apply more than 1100V peak between INPUT HI and LO, or 2×10^7V•Hz input, or instrument damage may occur.

5. Observe the display. If the "Overflow" message is shown, select a higher range until a normal reading is displayed. Always use the lowest possible range for the best resolution.
6. Take a reading from the display.

Voltage configuration

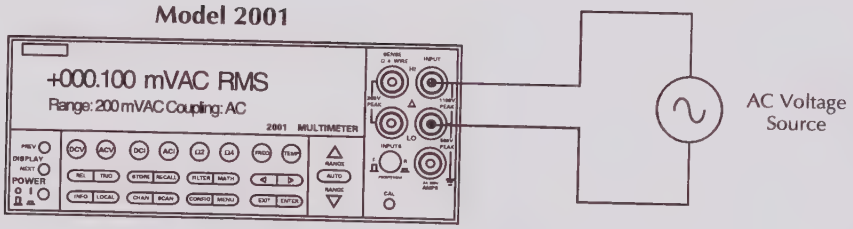
The following paragraphs detail how to change the Model 2001 from its bench reset conditions for DC and AC voltage measurements. The configuration menus are summarized in Tables 3-6 and 3-7. Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.



Input Resistance = 10MΩ on 1000V and 200V ranges ;
> 10GΩ on 20V, 2V and 200mV ranges.
= 1MΩ on DCV peak spikes measurement.

Caution: Maximum Input = 1100V peak

Figure 3-6
DC voltage measurements



Input Impedance = 1MΩ shunted by <140pF

Caution: Maximum Input = 1100V peak, 2 x 10^7 V•Hz

Figure 3-7
AC voltage measurements

Table 3-6
CONFIGURE DCV menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
ANALOG-FILTER	Enable (ON) or disable (OFF) analog filter.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.

Table 3-7
CONFIGURE ACV menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
UNITS	Display units menu:
VOLTS	Select volts.
dB	Select dB and set voltage reference level.
dBm	Select dBm and set reference impedance.
COUPLING	Coupling menu:
AC	Select AC coupled measurements.
AC+DC	Select DC coupled measurements.
AC-TYPE	Type of ACV measurement menu:
RMS	Select true RMS ACV.
AVERAGE	Select average ACV.
PEAK	Select peak ACV.
LOW-FREQ-RMS	Select low frequency (typically <50Hz) true RMS ACV.
POSITIVE-PEAK	Select positive DCV peak spikes measurements.
NEGATIVE-PEAK	Select negative DCV peak spikes measurements.

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measured (also known as aperture). The integration time affects the usable resolution, the amount of reading noise, as well as the ultimate reading rate of the instrument. Any triggers received while the instrument is processing a reading are ignored. From the front panel, the integration time is specified in parameters based on a number of power line cycles (NPLC), where 1 PLC for 60Hz is 16.67msec and 1 PLC for 50Hz and 400Hz is 20msec.

The optimum integration time setting for a given application depends on your measurement requirements. If speed is of primary importance, use the FAST (0.01 PLC) integration time at the expense of increased reading noise and less usable resolution. For maximum common-mode and normal-mode rejection, use the HIACCURACY (10 PLC) integration time. The NORMAL (1 PLC) and MEDIUM (0.1 PLC) can be used when a compromise between noise performance and speed is acceptable. The additional parameters for integration time, SET-SPEED-EXACTLY and SET-BY-RSLN, are discussed below.

You can program the integration time parameter as follows:

1. From the normal reading display, press the CONFIG key and then the appropriate function key to access the top level of a function configuration menu. For example, the CONFIGURE DCV menu is displayed as follows:

   CONFIGURE DCV
   SPEED FILTER RESOLUTION

2. Use the cursor keys (◄ and ►) to highlight SPEED and press ENTER. The following typical menu is shown:

   DCV MEASUREMENT SPEED
   NORMAL FAST MEDIUM HIACCURACY ►
   ◄ SET-SPEED-EXACTLY SET-BY-RSLN

3. Highlight the desired integration time and press ENTER. For all functions (except frequency), the parameters are as follows:

   NORMAL = 1 PLC
   FAST = 0.01 PLC
   MEDIUM = 0.1 PLC
   HIACCURACY = 10 PLC

There are two additional parameters, SET-SPEED-EXACTLY and SET-BY-RSLN. If the SET-SPEED-EXACTLY parameter is chosen, the following message is displayed:

NPLC=01.00 (.01-10)

By using the cursor keys (◄ and ►) and the RANGE ▲ and ▼ keys, you can enter the integration time expressed in power line cycles. Note that integer integrations time will increase noise rejection.

The SET-BY-RSLN parameter optimizes the integration time for the present resolution setting. See Table 3-8 for the default integration times of the DCV and ACV functions. The default set-by-resolution integration times of other functions are listed in paragraphs 3.4.2, 3.4.3, and 3.4.5.

ANALOG FILTER

The ANALOG-FILTER menu item is used to check and/or change the state of the analog filter for the DCV function. It is described in paragraph 3.9.

After selecting this menu item, cursor position indicates the present state (ON or OFF) of the analog filter. To change the state, place the cursor (using the ◄ and ► keys) on the alternate selection and press ENTER.

FILTER

The FILTER parameter lets you set the digital filter response and control its on/off operation. It is described in paragraph 3.9. Only the specifics for DC and AC voltage are covered here.

The AUTO parameter for a digital filter optimizes its use for the present measurement function. The defaults for automatic filtering of DCV and ACV are listed in Table 3-9.

Table 3-8
DCV and ACV integration times set-by-resolution

Measurement function and type	Resolution	Integration time
DCV	3.5d, 4.5d	0.01 PLC
	5.5d	0.02 PLC
	6.5d	0.20 PLC
	7.5d	2.00 PLC
DCV peak spikes	3.5d (to 7.5d)	Not used
RMS, average	3.5d, 4.5d	0.01 PLC
	5.5d	0.02 PLC
	6.5d, 7.5d	10.00 PLC
Low frequency RMS	3.5d to 7.5d	Not used
ACV peak	4d (to 8d)	Not used

Notes:
1. For DCV measurements, if the integration time is SET-BY-RSLN and the resolution AUTO, the integration time will be 1.0 PLC and the resolution 6.5 digits.
2. For RMS and average measurements, if the integration time is SET-BY-RSLN and the resolution is AUTO, the integration will be 1.0 PLC and the resolution 5.5 digits.
3. For DCV peak spikes, low frequency RMS, and ACV peak measurements, the integration time setting is ignored.
4. The resolution of DCV peak spikes can be from 3.5d to 7.5d, but the accuracy is specified at 3.5d. The resolution of ACV peak can be from 4d to 8d, but the accuracy is specified at 4d.

Table 3-9
DCV and ACV auto filter

Measurement function and type	Units	State	Type	Readings	Noise tolerance	Averaging Mode
DCV	-	On	Advanced	10	1.0%	Moving
DCV peak spikes	-	On	Advanced	10	5.0%	Moving
RMS, average, low frequency RMS	Any	Off	Advanced	10	5.0%	Moving
ACV peak	Volts	On	Advanced	10	5.0%	Moving
	dB, dBm	On	Averaging	10	-	Moving

RESOLUTION

Except for frequency, temperature, and some special cases of AC voltage, all functions can operate with 3.5, 4.5, 5.5, 6.5, or 7.5-digit resolution, or they can default to a setting appropriate for the selected integration time. You can program the resolution parameter as follows:

1. From the normal reading display, press the CONFIG key and then the appropriate function key to access the top level of a function configuration menu. For example, the CONFIGURE DCV menu is displayed as follows:

   CONFIGURE DCV
   SPEED FILTER RESOLUTION

2. Use the cursor keys (◄ and ►) to highlight RESOLUTION and press ENTER. The following typical menu is shown:

   SET DCV RESOLUTION
   AUTO 3.5d 4.5d 5.5d 6.5d 7.5d

3. Highlight the desired resolution and press ENTER.

The AUTO selection optimizes the resolution for the present integration time setting. See Table 3-10 for the default resolutions of the DCV and ACV functions. The default resolutions of other functions are listed in paragraphs 3.4.2, 3.4.3, and 3.4.5.

Table 3-10
DCV and ACV auto resolution

Measurement function and type	Integration time	Resolution
DCV	0.01 to <0.02 PLC	4.5d
	0.02 to <0.20 PLC	5.5d
	0.20 to <2.00 PLC	6.5d
	2.00 to 10.00 PLC	7.5d
DCV peak spikes	Not used	3.5d
RMS, average	0.01 to <0.02 PLC	4.5d
	0.02 to <10.00 PLC	5.5d
	10.00 PLC	6.5d
Low frequency RMS	Not used	5.5d
ACV peak	Not used	4d

Notes:
1. If the DCV resolution is AUTO and the integration time SET-BY-RSLN, the resolution will be 6.5 digits and the integration time 1.0 PLC.
2. For DCV peak spikes, low frequency RMS, and ACV peak measurements, the integration time setting is ignored.
3. For RMS and average measurements, if the resolution is AUTO and the integration time is SET-BY-RSLN, the resolution will be 5.5 digits and the integration time 1.0 PLC.

UNITS

This parameter selects the displayed units for AC voltage measurements. You can program the ACV units parameter as follows:

1. From the CONFIGURE ACV menu, select UNITS and press ENTER. The following menu is displayed:

   SET ACV DISP UNITS
   VOLTS dB dBm

2. Highlight the desired units and press ENTER.

VOLTS: With volts selected as the units, AC voltage measurements are expressed in volts.

dB: Expressing AC voltage in dB makes it possible to compress a large range of measurements into a much smaller scope. The relationship between dB and voltage is defined by the following equation:

$$dB = 20 \log \frac{V_{IN}}{V_{REF}}$$

where: V_{IN} is the AC input signal.
V_{REF} is the specified voltage reference level.

The instrument will read 0dB when the reference voltage level is applied to the input. dB measurements are possible on all ACV measurement types except positive peak spikes and negative peak spikes, as these may be negative, and the log of a negative number is not defined. Note that dB measurements are specified only for the low frequency RMS measurement type.

If a relative value is in effect when dB is selected, the value is converted to dB. If a relative value is stored after dB units are selected, the units of the relative value are dB.

To set the reference voltage level, perform the following steps:

1. From the SET ACV DISP UNITS menu, select the dB option. The following typical message is shown:

   dB REF LEV:001.000 V

2. By using the cursor keys (◄ and ►) and the RANGE ▲ and ▼ keys, you can enter the desired voltage reference level (0.001V to 750V).
3. Press ENTER to complete the change. If positive peak spikes or negative peak spikes is the selected AC type, the change is not allowed.

dBm: dBm is defined as decibels above or below a 1mW reference. With a user-programmable reference impedance, the Model 2001 reads 0dBm when the voltage needed to dissipate 1mW through the reference impedance is applied. The relationship between dBm, a reference impedance, and the voltage is defined by the following equation:

$$dBm = 10 \log \frac{(V_{IN}^2/Z_{REF})}{1mW}$$

where: V_{IN} is the AC input signal.
Z_{REF} is the specified reference impedance.

NOTE

Do not confuse reference impedance with input impedance. The input impedance of the instrument is not modified by the dBm parameter.

If a relative value is in effect when dBm is selected, the value is converted to dBm. If a relative value is stored after dB units are selected, the units of the relative value is dBm.

To set the reference impedance, perform the following steps:

1. From the SET ACV DISP UNITS menu, select the dBm option. The following menu is shown:

   SET dBm REFERENCE
   50Ω 75Ω 93Ω 132Ω 300Ω 600Ω

2. Highlight the desired reference impedance and press ENTER to complete the change. If positive peak spikes or negative peak spikes is the selected AC type, the change is not allowed.

dB/dBm notes:

1. dB and dBm units are not allowed with positive or negative peak spike measurements.
2. dB and dBm units are not allowed with an advanced filter.
3. With dB or dBm units selected, there is no bar graph on zero-centered bar graph multiple display.
4. When units are changed from volts to dB or dBm with A02 and greater firmware, all values less than zero that depend on the new units are made equal to zero. This includes, for example, relative values and stored readings. This avoids the overflow condition of a log of a negative number.

COUPLING

This parameter selects the input coupling for the ACV function. When AC coupling is selected, a DC blocking capacitor is placed in series with the input. This removes the DC component from the RMS, average, or peak ACV measurement.

When AC+DC coupling is selected, the blocking capacitor is removed. Subsequent RMS, average, or peak ACV measurements will reflect both the AC and DC components of the signal.

While displaying readings, the present coupling setting is shown on the bottom line, if not showing a multiple display.

You can set the ACV coupling as follows:

1. From the CONFIGURE ACV menu, select COUPLING and press ENTER. The following menu is displayed:

   SET AC COUPLING
   AC AC+DC

2. Highlight the desired coupling and press ENTER.

Note that the coupling settings for ACV and ACI are discrete. Thus, setting the coupling of ACV has no effect on the coupling of ACI.

AC-TYPE

This parameter selects the measurement type for the ACV function. The Model 2001 directly measures RMS, average, and peak AC voltages. For a 330V peak-to-peak sine wave, which is line voltage in the U.S., the measurements would be:

- RMS = 117V
- Average = 105V (full wave rectified)
- Peak AC = 165V

The peak detector is also used to measure positive and negative peak spikes riding on a DC signal and they are, therefore, also configured from the AC-TYPE menu.

You can program the ACV type parameter as follows:

1. From the CONFIGURE ACV menu, select AC-TYPE and press ENTER. The following menu is displayed:

   SET ACV MEASUREMENT
   RMS AVERAGE PEAK LOW-FREQ-RMS ▶
   ◀ POSITIVE-PEAK NEGATIVE-PEAK

2. Highlight the desired measurement type and press ENTER.

RMS and LOW-FREQ-RMS: Selecting between normal RMS mode and low frequency RMS mode depends on the desired accuracy and speed. Low frequency RMS mode is more accurate, but slower.

Both modes are specified between 20Hz and 2MHz, with low frequency RMS specified additionally down to 1Hz. Some guidelines for choosing between the two modes follow:

- Below 50Hz, use low frequency RMS mode for its greater accuracy.
- Between 50 and 100Hz, use either mode.
- Above 100Hz, use normal RMS mode for its greater speed.

AVERAGE: When this item is selected, the signal path in the instrument bypasses the RMS converter, so the average ACV measurement is just the filtered output of a full wave rectifier.

PEAK: For AC peak measurements, the instrument displays the largest peak (positive or negative) of the input signal. The measurement window is fixed at 100msec.

Note that you can configure the resolution of ACV peak measurements from 4 digits (3.5d from SET ACV RESOLUTION menu) to 8 digits (7.5d), but the accuracy is specified at 4 digits. In addition, the accuracy specifications for AC peak measurements assume AC+DC coupling below 200Hz.

POSITIVE-PEAK and NEGATIVE-PEAK: Peak spike measurements are available as an ACV primary display (top line). They are also available as a DCV multiple display (bottom line). The menu items POSITIVE-PEAK and NEGATIVE-PEAK enable the measurement as a primary display. See Figure 3-8 for a description of the primary display.

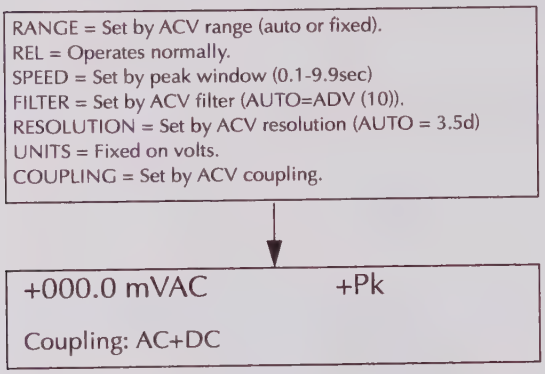
After selecting a positive or negative peak spikes measurement from the SET ACV MEASUREMENT menu, you are asked to enter a value for the measurement window. A typical message follows:

PEAK WINDOW = 0.1 s

This sets the time the signal is sampled before the display is updated with a new reading. It can range from 0.1sec to 9.9sec.

As a primary display, the resolution of peak spikes can be set from 3.5d to 7.5d, but the accuracy is specified at 3.5d. (As a multiple display, the resolution is fixed at 3.5d.)

Note that dB and dBm are not allowed as valid units for peak spikes. Positive-going spikes on a negative DC level could still read as a negative value, and the log of a negative number is not defined.

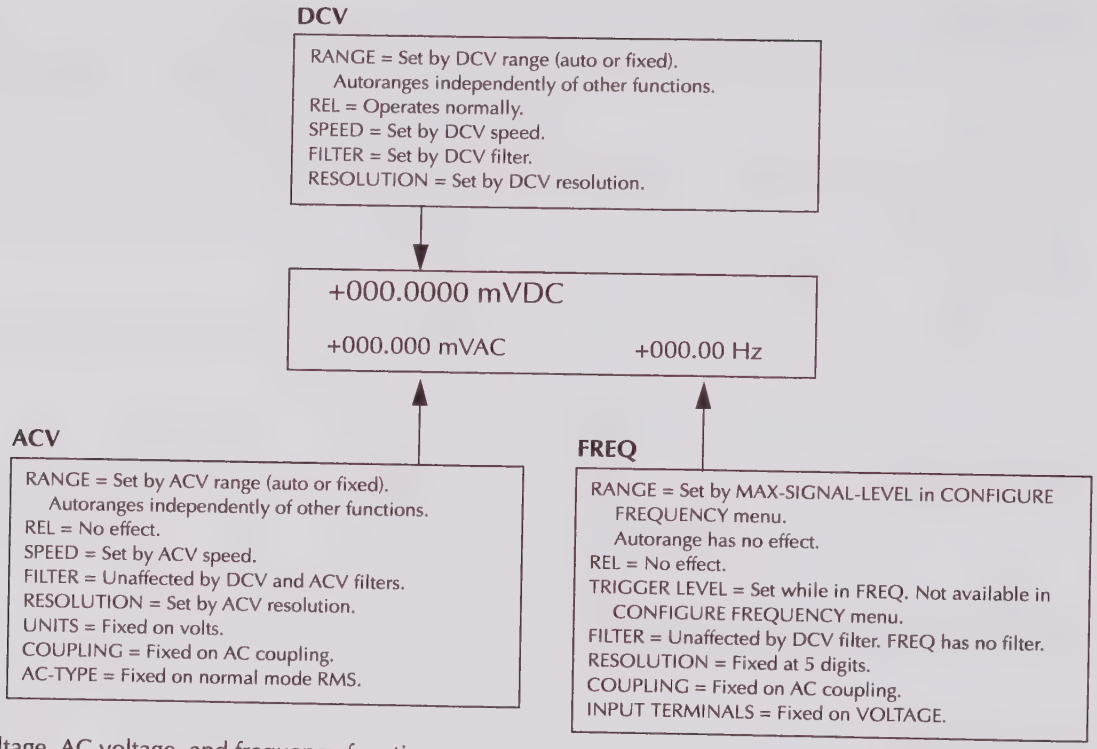

RANGE = Set by ACV range (auto or fixed).
REL = Operates normally.
SPEED = Set by peak window (0.1-9.9sec)
FILTER = Set by ACV filter (AUTO=ADV (10)).
RESOLUTION = Set by ACV resolution (AUTO = 3.5d)
UNITS = Fixed on volts.
COUPLING = Set by ACV coupling.
+000.0 mVAC
+Pk
Coupling: AC+DC

NOTES:
1. Positive peak spikes and negative peak spikes are selected in the CONFIGURE-ACV menu.
2. Peak spikes measurement is specified for volts at 3.5 digits.
3. "Peak window" is the time a signal is sampled before a reading is displayed.

Figure 3-8
Positive and negative peak spikes

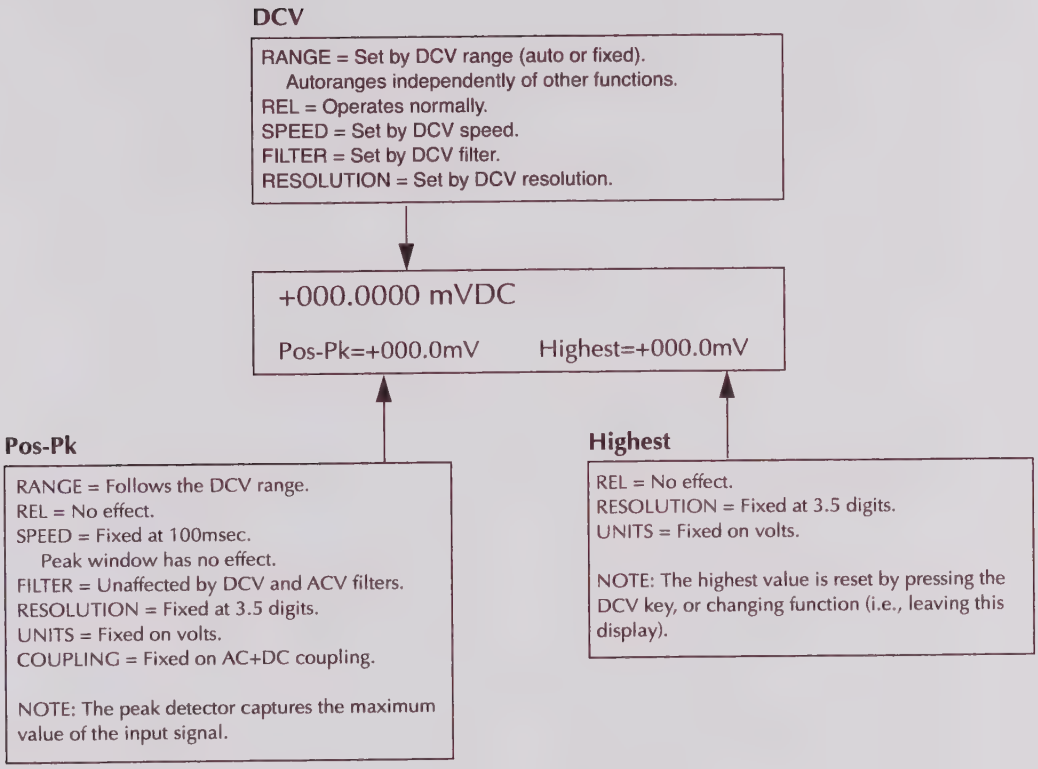
Multiple displays

The displays for DC and AC voltage that show multiple functions are shown in Figures 3-9 and 3-10. The multiple display for crest factor, which is calculated from the peak and RMS values, is described here.


DCV
RANGE = Set by DCV range (auto or fixed).
Autoranges independently of other functions.
REL = Operates normally.
SPEED = Set by DCV speed.
FILTER = Set by DCV filter.
RESOLUTION = Set by DCV resolution.
+000.0000 mVDC
+000.000 mVAC
+000.00 Hz
ACV
RANGE = Set by ACV range (auto or fixed).
Autoranges independently of other functions.
REL = No effect.
SPEED = Set by ACV speed.
FILTER = Unaffected by DCV and ACV filters.
RESOLUTION = Set by ACV resolution.
UNITS = Fixed on volts.
COUPLING = Fixed on AC coupling.
AC-TYPE = Fixed on normal mode RMS.
FREQ
RANGE = Set by MAX-SIGNAL-LEVEL in CONFIGURE FREQUENCY menu.
Autorange has no effect.
REL = No effect.
TRIGGER LEVEL = Set while in FREQ. Not available in CONFIGURE FREQUENCY menu.
FILTER = Unaffected by DCV filter. FREQ has no filter.
RESOLUTION = Fixed at 5 digits.
COUPLING = Fixed on AC coupling.
INPUT TERMINALS = Fixed on VOLTAGE.

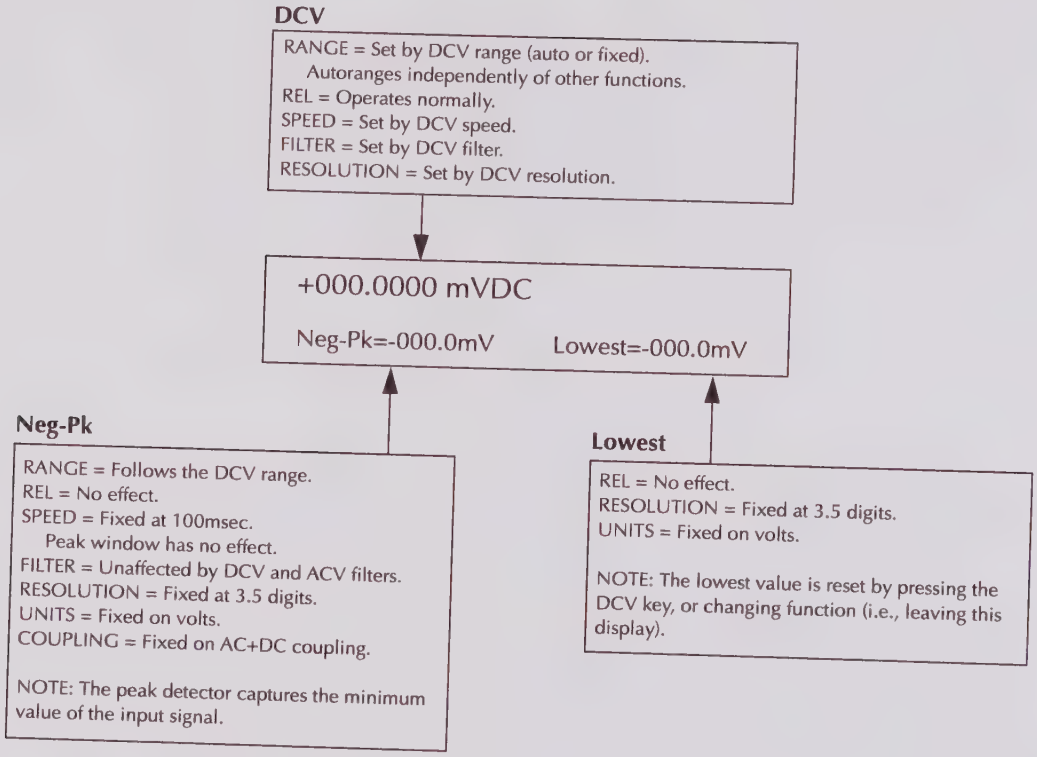
A. DC voltage, AC voltage, and frequency functions

Figure 3-9
DC voltage multifunction multiple displays


DCV
RANGE = Set by DCV range (auto or fixed).
Autoranges independently of other functions.
REL = Operates normally.
SPEED = Set by DCV speed.
FILTER = Set by DCV filter.
RESOLUTION = Set by DCV resolution.
+000.0000 mVDC
Pos-Pk=+000.0mV
Highest=+000.0mV
Pos-Pk
RANGE = Follows the DCV range.
REL = No effect.
SPEED = Fixed at 100msec.
Peak window has no effect.
FILTER = Unaffected by DCV and ACV filters.
RESOLUTION = Fixed at 3.5 digits.
UNITS = Fixed on volts.
COUPLING = Fixed on AC+DC coupling.
NOTE: The peak detector captures the maximum value of the input signal.
Highest
REL = No effect.
RESOLUTION = Fixed at 3.5 digits.
UNITS = Fixed on volts.
NOTE: The highest value is reset by pressing the DCV key, or changing function (i.e., leaving this display).

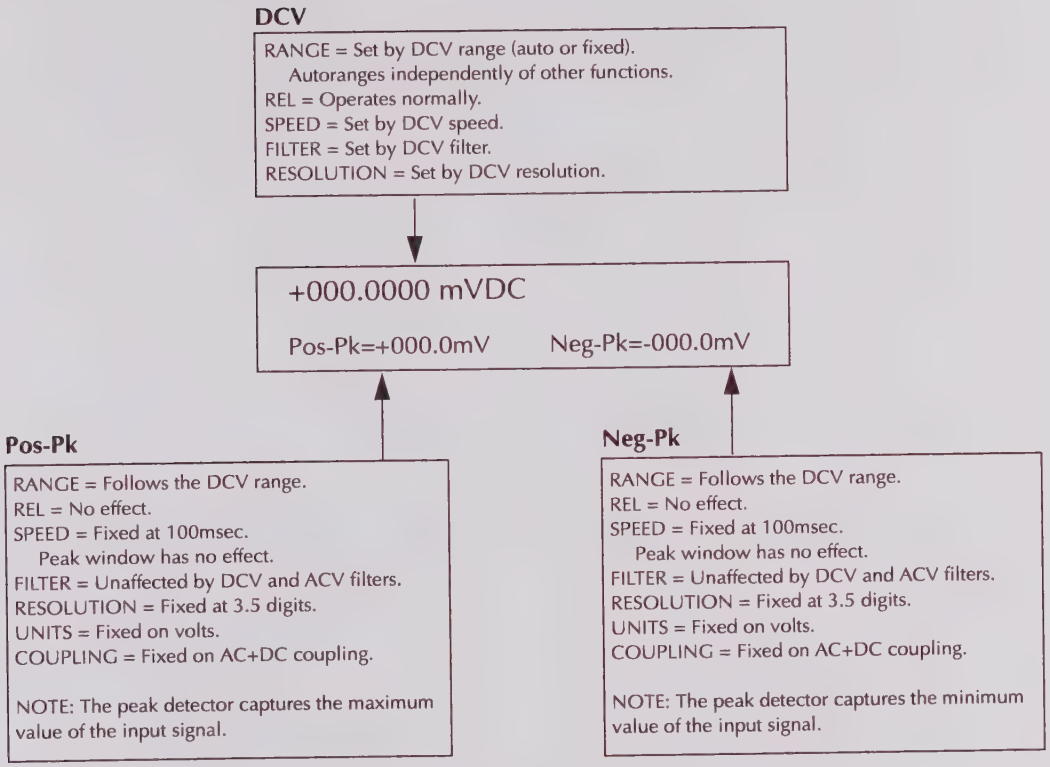
B. DC voltage and positive peak spikes functions

Figure 3-9 (continued)
DC voltage multifunction multiple displays


DCV
RANGE = Set by DCV range (auto or fixed).
Autoranges independently of other functions.
REL = Operates normally.
SPEED = Set by DCV speed.
FILTER = Set by DCV filter.
RESOLUTION = Set by DCV resolution.
+000.0000 mVDC
Neg-Pk=-000.0mV
Lowest=-000.0mV
Neg-Pk
RANGE = Follows the DCV range.
REL = No effect.
SPEED = Fixed at 100msec.
Peak window has no effect.
FILTER = Unaffected by DCV and ACV filters.
RESOLUTION = Fixed at 3.5 digits.
UNITS = Fixed on volts.
COUPLING = Fixed on AC+DC coupling.
NOTE: The peak detector captures the minimum value of the input signal.
Lowest
REL = No effect.
RESOLUTION = Fixed at 3.5 digits.
UNITS = Fixed on volts.
NOTE: The lowest value is reset by pressing the DCV key, or changing function (i.e., leaving this display).

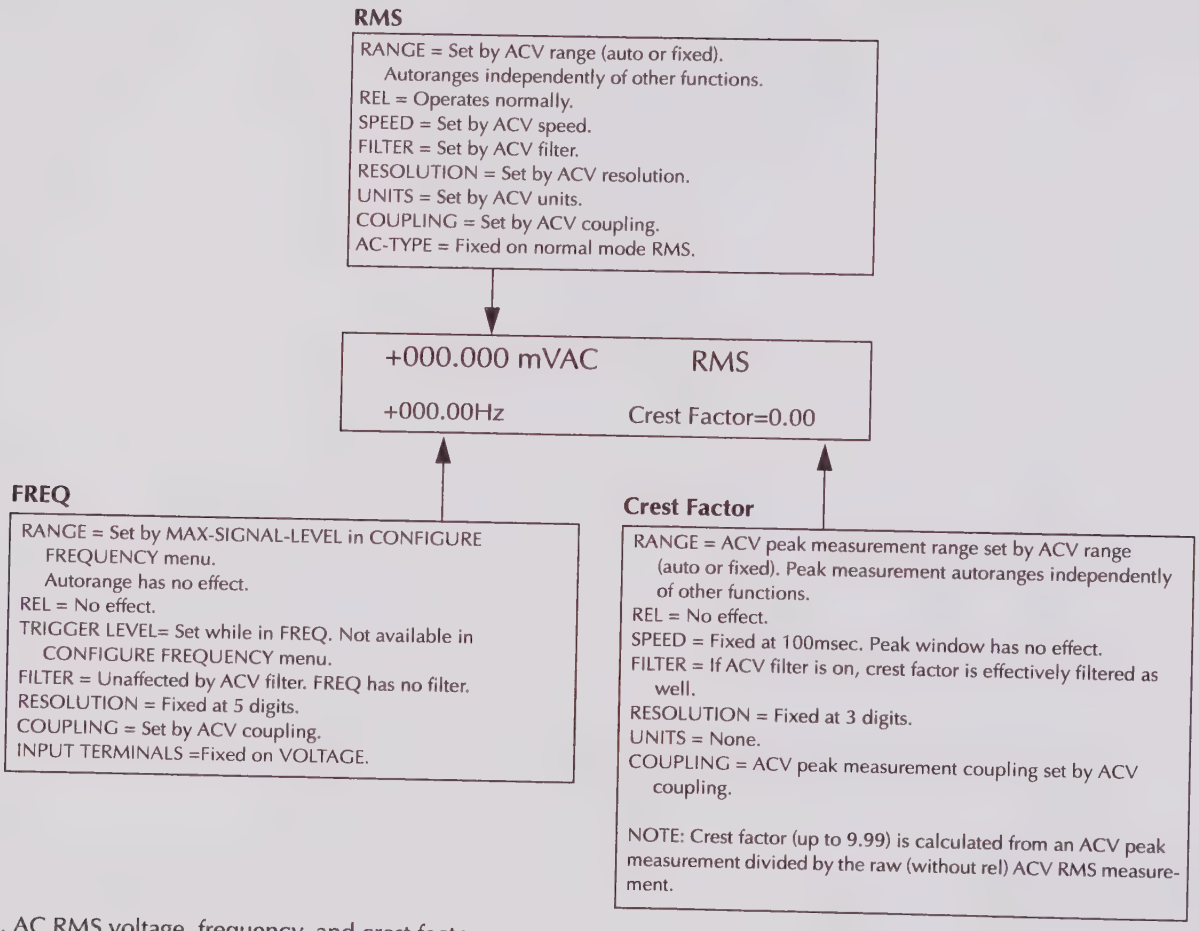
C. DC voltage and negative peak spikes functions

Figure 3-9 (continued)
DC voltage multifunction multiple displays


DCV
RANGE = Set by DCV range (auto or fixed).
Autoranges independently of other functions.
REL = Operates normally.
SPEED = Set by DCV speed.
FILTER = Set by DCV filter.
RESOLUTION = Set by DCV resolution.
+000.0000 mVDC
Pos-Pk=+000.0mV
Neg-Pk=-000.0mV
Pos-Pk
RANGE = Follows the DCV range.
REL = No effect.
SPEED = Fixed at 100msec.
Peak window has no effect.
FILTER = Unaffected by DCV and ACV filters.
RESOLUTION = Fixed at 3.5 digits.
UNITS = Fixed on volts.
COUPLING = Fixed on AC+DC coupling.
NOTE: The peak detector captures the maximum value of the input signal.
Neg-Pk
RANGE = Follows the DCV range.
REL = No effect.
SPEED = Fixed at 100msec.
Peak window has no effect.
FILTER = Unaffected by DCV and ACV filters.
RESOLUTION = Fixed at 3.5 digits.
UNITS = Fixed on volts.
COUPLING = Fixed on AC+DC coupling.
NOTE: The peak detector captures the minimum value of the input signal.

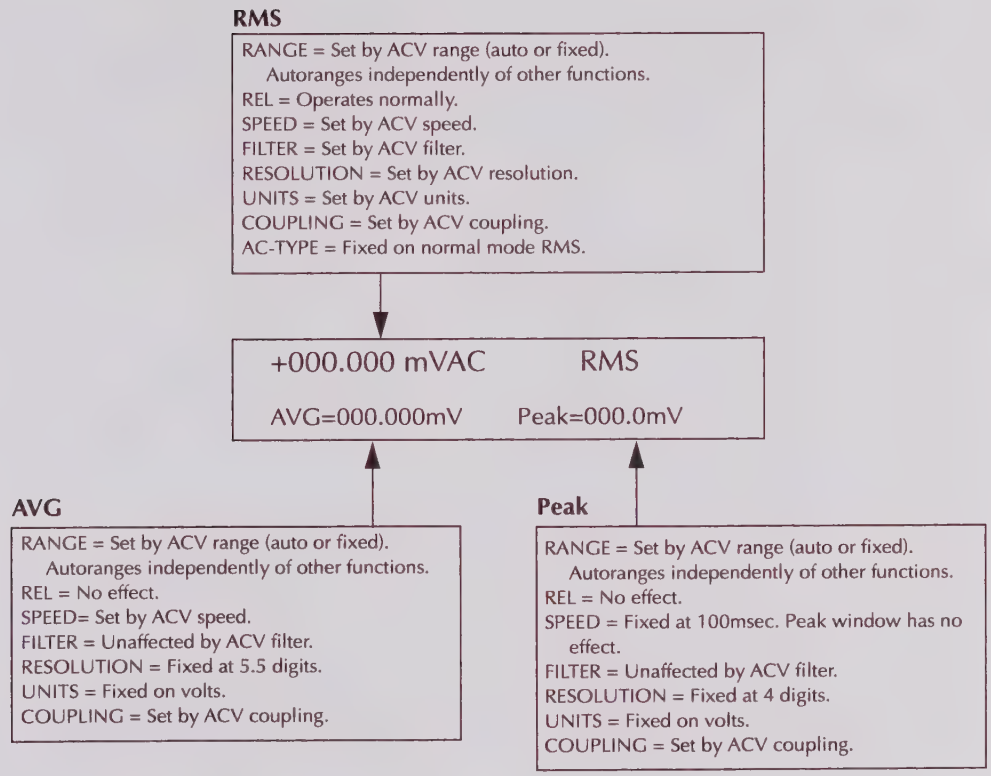
D. DC voltage, positive and negative peak spikes functions

Figure 3-9 (continued)
DC voltage multifunction multiple displays


RMS
RANGE = Set by ACV range (auto or fixed).
Autoranges independently of other functions.
REL = Operates normally.
SPEED = Set by ACV speed.
FILTER = Set by ACV filter.
RESOLUTION = Set by ACV resolution.
UNITS = Set by ACV units.
COUPLING = Set by ACV coupling.
AC-TYPE = Fixed on normal mode RMS.
+000.000 mVAC
RMS
+000.00Hz
Crest Factor=0.00
FREQ
RANGE = Set by MAX-SIGNAL-LEVEL in CONFIGURE FREQUENCY menu.
Autorange has no effect.
REL = No effect.
TRIGGER LEVEL= Set while in FREQ. Not available in CONFIGURE FREQUENCY menu.
FILTER = Unaffected by ACV filter. FREQ has no filter.
RESOLUTION = Fixed at 5 digits.
COUPLING = Set by ACV coupling.
INPUT TERMINALS =Fixed on VOLTAGE.
Crest Factor
RANGE = ACV peak measurement range set by ACV range (auto or fixed). Peak measurement autoranges independently of other functions.
REL = No effect.
SPEED = Fixed at 100msec. Peak window has no effect.
FILTER = If ACV filter is on, crest factor is effectively filtered as well.
RESOLUTION = Fixed at 3 digits.
UNITS = None.
COUPLING = ACV peak measurement coupling set by ACV coupling.
NOTE: Crest factor (up to 9.99) is calculated from an ACV peak measurement divided by the raw (without rel) ACV RMS measurement.

A. AC RMS voltage, frequency, and crest factor

Figure 3-10
AC voltage multifunction multiple displays


RMS
RANGE = Set by ACV range (auto or fixed).
Autoranges independently of other functions.
REL = Operates normally.
SPEED = Set by ACV speed.
FILTER = Set by ACV filter.
RESOLUTION = Set by ACV resolution.
UNITS = Set by ACV units.
COUPLING = Set by ACV coupling.
AC-TYPE = Fixed on normal mode RMS.
+000.000 mVAC RMS
AVG=000.000mV Peak=000.0mV
AVG
RANGE = Set by ACV range (auto or fixed).
Autoranges independently of other functions.
REL = No effect.
SPEED= Set by ACV speed.
FILTER = Unaffected by ACV filter.
RESOLUTION = Fixed at 5.5 digits.
UNITS = Fixed on volts.
COUPLING = Set by ACV coupling.
Peak
RANGE = Set by ACV range (auto or fixed).
Autoranges independently of other functions.
REL = No effect.
SPEED = Fixed at 100msec. Peak window has no effect.
FILTER = Unaffected by ACV filter.
RESOLUTION = Fixed at 4 digits.
UNITS = Fixed on volts.
COUPLING = Set by ACV coupling.

B. AC RMS, average, and peak voltages

Figure 3-10 (continued)
AC voltage multifunction multiple displays

Crest factor: The crest factor of a waveform is the ratio of its peak value to its RMS value. Thus, the crest factor specifies the dynamic range of a true RMS instrument. For sinusoidal waveforms, the crest factor is 1.414. For a symmetrical square wave, the crest factor is unity. The crest factor of a rectangular pulse is related to its duty cycle; as the duty cycle decreases, the crest factor increases.

For the Model 2001, the additional error term for RMS measurements caused by a high crest factor is specified up to a value of five. The maximum displayable value is 9.99, or else it shows "over".

Note that the crest factor is not calculated if dB or dBm is the presently selected units.

Low level considerations

For sensitive measurements, external considerations besides the Model 2001 affect the accuracy. Effects not noticeable when working with higher voltages are significant in microvolt signals. The Model 2001 reads only the signal received at its input; therefore, it is important that this signal be properly transmitted from the source. The following paragraphs indicate factors that affect accuracy, including thermal offsets and stray pick-up.

Shielding: AC voltages that are extremely large compared with the DC signal to be measured may produce an erroneous output. Therefore, to minimize AC interference, the circuit should be shielded with the shield connected to the Model 2001 INPUT LO (particularly for low-level sources). Improper shielding can cause the Model 2001 to behave in one or more of the following ways:

- Unexpected offset voltages.
- Inconsistent readings between ranges.
- Sudden shifts in reading.

To minimize pick-up, keep the voltage source and the Model 2001 away from strong AC magnetic sources. The voltage induced due to magnetic flux is proportional to the area of the loop formed by the input leads. Therefore, minimize the loop area of the input leads and connect each signal at only one point.

Thermal EMFs: Thermal emfs (thermoelectric potentials) are generated by thermal differences between the junctions of dissimilar metals. These can be large compared to the signal that the Model 2001 can measure. Thermal emfs can cause the following conditions:

- Instability or zero offset is much higher than expected.
- The reading is sensitive to (and responds to) temperature changes. This effect can be demonstrated by touching the circuit, by placing a heat source near the circuit, or by a regular pattern of instability (corresponding to heating and air conditioning systems, or changes in sunlight).

To minimize the drift caused by thermal emfs, use copper leads to connect the circuit to the Model 2001. A banana plug generates a few microvolts. A clean copper conductor such as #10 bus wire is ideal for this application. The leads to the input may be shielded or unshielded, as necessary. Refer to Shielding.

Widely varying temperatures within the circuit can also create thermal emfs. Therefore, maintain constant offset temperatures to minimize these thermal emfs. A cardboard box around the circuit under test also helps by minimizing air currents.

The REL control can be used to null out constant offset voltages.

Note that additional thermals may be generated by the optional Model 2001-SCAN scanner card.

AC voltage offset: The Model 2001, at 5½d resolution, will typically display 150 counts of offset on AC volts with the input shorted. This offset is caused by the offset of the TRMS converter. This offset will not affect reading accuracy and should not be zeroed out using the rel feature. The following equation expresses how this offset (V_{OFFSET}) is added to the signal input (V_{IN}):

$$\text{Displayed reading} = \sqrt{(V_{IN})^2 + (V_{OFFSET})^2}$$

Example: Range = 2VAC
Offset = 150 counts (1.5mV)
Input = 200mV RMS

$$\text{Display reading} = \sqrt{(200\text{mV})^2 + (1.5\text{mV})^2}$$

$$= \sqrt{0.04\text{V} + (2.25 \times 10^{-6} V)}$$

$$= .200005\text{V}$$

The offset is seen as the last digit which is not displayed. Therefore, the offset is negligible. If the rel feature were used to zero the display, the 150 counts of offset would be subtracted from V_{IN} resulting in an error of 150 counts in the displayed reading.

3.4.2 DC and AC current

DC current measurements

The Model 2001 can make normal DC current measurements between 10pA and 2.1A. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect the test leads to the AMPS and INPUT LO terminals of the Model 2001. Either the front or rear inputs can be used; place the INPUTS button in the appropriate position.
2. Select the DCI function.
3. Select a range consistent with the expected current. For automatic range selection, press the AUTO key. The AUTO annunciator denotes whether auto-ranging is enabled.
4. Connect the test leads to the source as shown in Figure 3-11.

CAUTION

Do not apply more than 2.1A, 250V to the AMPS input, or the amps protection fuse will blow.

5. Observe the display. If the "Overflow" message is shown, select a higher range until a normal reading is displayed. Always use the lowest possible range for the best resolution.
6. Take a reading from the display.

AC current measurements

The Model 2001 can make AC current measurements between 100pA and 2.1A. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect the test leads to the AMPS and INPUT LO terminals of the Model 2001. Either the front or rear inputs can be used; place the INPUTS button in the appropriate position.
2. Select the ACI function.
3. Select a range consistent with the expected current. For automatic range selection, press the AUTO key. The AUTO annunciator denotes whether auto-ranging is enabled.
4. Connect the test leads to the source as shown in Figure 3-11.

CAUTION

Do not apply more than 2.1A, 250V to the AMPS input, or the amps protection fuse will blow.

5. Observe the display. If the "Overflow" message is shown, select a higher range until a normal reading is displayed. Always use the lowest possible range for the best resolution.
6. Take a reading from the display.

AMPS fuse replacement

There are two protection fuses for the current ranges, one for the front terminals, another for the rear. This procedure describes how to change an AMPS fuse.

WARNING

Make sure the instrument is disconnected from the power line and other equipment before replacing an AMPS fuse.

1. Turn off the power and disconnect the power line and test leads.
2. Perform one of the following steps:
   A. For the front panel AMPS fuse, gently push in the AMPS jack with your thumb and rotate the fuse carrier one-quarter turn counter-clockwise. Release pressure on the jack and its internal spring will push the jack out of the socket.
   B. For the rear panel AMPS fuse, place the end of a flat-blade screwdriver into the rear panel AMPS holder. Push in gently and rotate the fuse carrier one-quarter turn counter-clockwise. Release pressure on the holder and its internal spring will push the fuse carrier out of the holder.
3. Remove the fuse and replace it with the same type (2A, 250V, fast blow, 5 × 20mm). The Keithley part number is FU-48.

CAUTION

Do not use a fuse with a higher current rating than specified, or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse. See the optional Model 2001 Repair Manual for troubleshooting information.

4. Install the new fuse by reversing the above procedure.

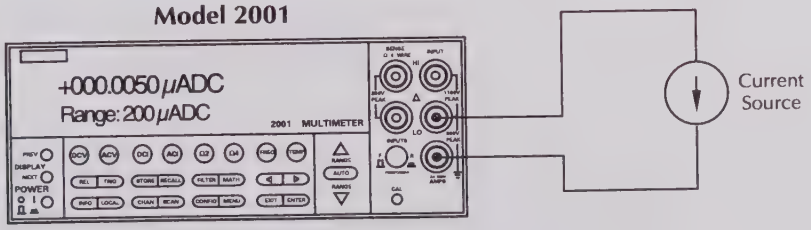


Figure 3-11
DC and AC current measurements

Current configuration

The following paragraphs detail how to change the Model 2001 from its bench reset conditions for DC and AC current measurements. The configuration menus are summarized in Tables 3-11 and 3-12. Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 3-11
CONFIGURE DCI menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
MEASUREMENT-MODE	Measurement mode menu:
NORMAL	Select normal current measurement (use AMPS terminals).
IN-CIRCUIT	Select in-circuit current measurement (use INPUT and SENSE terminals).

Table 3-12
CONFIGURE ACI menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
COUPLING	Coupling menu:
AC	Select AC coupled measurements.
AC+DC	Select DC coupled measurements.
AC-TYPE	Type of ACI measurement menu:
RMS	Select true RMS ACI.
AVERAGE	Select average ACI.

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measured (also known as aperture). It is discussed in paragraph 3.4.1, DC and AC voltage. Only the differences for DC and AC current are noted here.

The SET-BY-RSLN parameter optimizes the integration time for the present resolution setting. The defaults for set-by-resolution integration times of DCI and ACI are listed in Table 3-13.

Table 3-13
DCI and ACI integration time set-by-resolution

Measurement function and type	Resolution	Integration time
DC current	3.5d, 4.5d	0.01 PLC
	5.5d	0.02 PLC
	6.5d	0.20 PLC
	7.5d	2.00 PLC
DC in-circuit current	3.5d to 7.5d	Not used
RMS, average	3.5d, 4.5d	0.01 PLC
	5.5d	0.02 PLC
	6.5d, 7.5d	10.00 PLC

Notes:
1. For normal DC current, if the integration time is SET-BY-RSLN and the resolution is AUTO, the integration time will be 1.0 PLC and the resolution 6.5 digits.
2. For DC in-circuit current, the integration time setting is ignored.
3. For AC current, if the integration time is SET-BY-RSLN and the resolution is AUTO, the integration time will be 1.0 PLC and the resolution 5.5 digits.

FILTER

The FILTER parameter lets you set the digital filter response and control its on/off operation. It is described in paragraph 3.9. Only the specifics for DC and AC current are covered here.

The AUTO parameter for a digital filter optimizes its use for the present measurement function. The defaults for automatic filtering of DCI and ACI are listed in Table 3-14.

RESOLUTION

The RESOLUTION parameter sets the display resolution. It is discussed in paragraph 3.4.1, DC and AC voltage. Only the differences for DC and AC current are noted here.

The available resolution on all current functions and types is 3.5 digits to 7.5 digits. If the DCI or ACI resolution is AUTO, refer to Table 3-15 for the resolution associated with the integration time.

Table 3-14
DCI and ACI auto filter

Measurement function and type	State	Type	Readings	Noise tolerance	Mode
DC current	On	Advanced	10	1.0%	Moving
DC in-circuit current	On	Advanced	10	1.0%	Moving
AC current	Off	Advanced	10	5.0%	Moving

Table 3-15
DCI and ACI auto resolution

Measurement function and type	Integration time	Resolution
DC current	0.01 to <0.02 PLC	4.5d
	0.02 to <0.20 PLC	5.5d
	0.20 to <2.00 PLC	6.5d
	2.00 to 10.00 PLC	7.5d
DC in-circuit current	Not used	5.5d
RMS, average	0.01 to <0.02 PLC	4.5d
	0.02 to <10.00 PLC	5.5d
	10.00 PLC	6.5d

Notes:
1. For normal DC current, if the resolution is AUTO and the integration time is SET-BY-RSLN, the resolution will be 6.5 digits and the integration time 1.0 PLC.
2. For DC in-circuit current, the integration time setting is ignored.
3. For AC current, if the resolution is AUTO and the integration time is SET-BY-RSLN, the resolution will be 5.5 digits and the integration time 1.0 PLC.

MEASUREMENT-MODE

This option selects the DC current measurement mode, either normal or in-circuit measurements. It is programmed as follows:

1. From the CONFIGURE DCI menu, select MEASUREMENT-MODE and press ENTER. The following menu is shown:

   DCI MEASUREMENT MODE
   NORMAL IN-CIRCUIT

2. Highlight the desired mode and press ENTER.

NORMAL: This option is for normal current measuring, where the meter is placed in series with the current path and the voltage across an internal shunt resistor is measured. The specifications are derated by 50ppm for currents over 0.5A because of the self-heating effects on the shunt resistor.

IN-CIRCUIT: In-circuit current is a calculation based on a 4-wire resistance measurement and a voltage measurement. It is similar to an offset-compensated ohms reading.

A measurement overflow occurs for any of the following conditions:

- The measured voltage exceeds |±200mV|.
- The trace resistance is less than 1mΩ or greater than 10Ω.
- The in-circuit current is greater than 12A.

The current in a low resistance conductor (e.g., a printed circuit trace) can be measured without breaking the current path. The Model 2001 can do this with a pair of Kelvin test probes across the conductor. See Figure 3-12. The method follows:

1. Using one set of the Kelvin probe tips, the instrument sources a known current (I_{SOURCE}) through the conductor and simultaneously measures the resulting voltage (V_{MEAS1}) with the other set of probe tips:

$$V_{MEAS1} = (I_{IN\text{-}CKT} + I_{SOURCE})R_{TRACE}$$

or

$$R_{TRACE} = \frac{V_{MEAS1}}{(I_{IN\text{-}CKT} + I_{SOURCE})}$$

2. The instrument then measures the voltage (V_{MEAS2}) across the conductor without sourcing an additional current:

$$V_{MEAS2} = (I_{IN\text{-}CKT})R_{TRACE}$$

or

$$R_{TRACE} = \frac{V_{MEAS2}}{(I_{IN\text{-}CKT})}$$

3. It then calculates the in-circuit current by combining the equations and solving for $I_{IN\text{-}CKT}$:

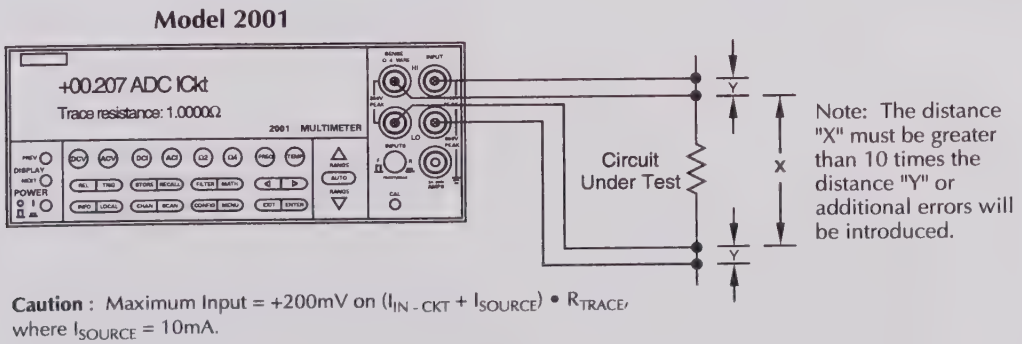
$$\frac{V_{MEAS1}}{(I_{IN\text{-}CKT} + I_{SOURCE})} = \frac{V_{MEAS2}}{(I_{IN\text{-}CKT})}$$

$$V_{MEAS1}(I_{IN\text{-}CKT}) = V_{MEAS2}(I_{IN\text{-}CKT} + I_{SOURCE})$$

$$V_{MEAS1}(I_{IN\text{-}CKT}) - V_{MEAS2}(I_{IN\text{-}CKT}) = V_{MEAS2}(I_{SOURCE})$$

$$I_{IN\text{-}CKT}(V_{MEAS1} - V_{MEAS2}) = V_{MEAS2}(I_{SOURCE})$$

$$I_{IN\text{-}CKT} = \frac{V_{MEAS2}(I_{SOURCE})}{(V_{MEAS1} - V_{MEAS2})}$$



Caution: Maximum Input = +200mV on ($I_{IN\text{-}CKT} + I_{SOURCE}$) • R_{TRACE}, where I_{SOURCE} = 10mA.

Figure 3-12
DC in-circuit current measurements

Because of accuracy considerations, in-circuit current readings are limited to traces with a resistance of 1mΩ to 10Ω. If either of these limits is exceeded in the resistance calculation, the in-circuit current cannot be calculated. The bottom line of the front panel display will show and update the trace resistance.

A procedure to measure in-circuit current follows:

1. Select the in-circuit current measurement mode from the CONFIGURE DCI menu and place the instrument in the DCI function. Note that the 4W annunciator lights to indicate this is a 4-wire measurement.
2. Connect a set of Kelvin test probes, such as Keithley Model 5805 or 5806, to the Model 2001 INPUT HI and LO terminals and SENSE HI and LO terminals.
3. For R_{TRACE} <50mΩ, or where the conductors are physically hot, rel out (zero correct) any thermal offsets that are present before measuring in-circuit current. With power to the test circuit removed, place the probes on the desired trace and enable rel from the DCI function.
4. Turn on the power to the test circuit and read the in-circuit current calculation. The speed of this measurement is four readings per second at 1PLC. Its range is fixed at 12A. The default filter for in-circuit current is a moving average of ten readings. Additional filtering may be needed at low voltage levels.

COUPLING

This parameter selects the input coupling for the ACI function. When AC coupling is selected, a DC blocking capacitor is placed in series with the AC measurement circuit. (Note that the current shunt resistors are always DC coupled to the inputs.) This removes the DC component from the RMS and average ACI measurement.

When AC+DC coupling is selected, the blocking capacitor is removed. Subsequent RMS or average ACI measurements will reflect both the AC and DC components of the signal.

You can set the ACI coupling as follows:

1. From the CONFIGURE ACI menu, select COUPLING and press ENTER. The following menu is displayed:

   SET AC COUPLING
   AC AC+DC

2. Highlight the desired coupling and press ENTER.

Note that the coupling settings for ACI and ACV are discrete. Thus, setting the coupling of ACI has no effect on the coupling of ACV.

AC-TYPE

This parameter selects the measurement type for the ACI function. The Model 2001 directly measures RMS and average AC current. You can program the ACI type parameter as follows:

1. From the CONFIGURE ACI menu, select AC-TYPE and press ENTER. The following menu is displayed:

   SET ACI MEASUREMENT
   RMS AVERAGE

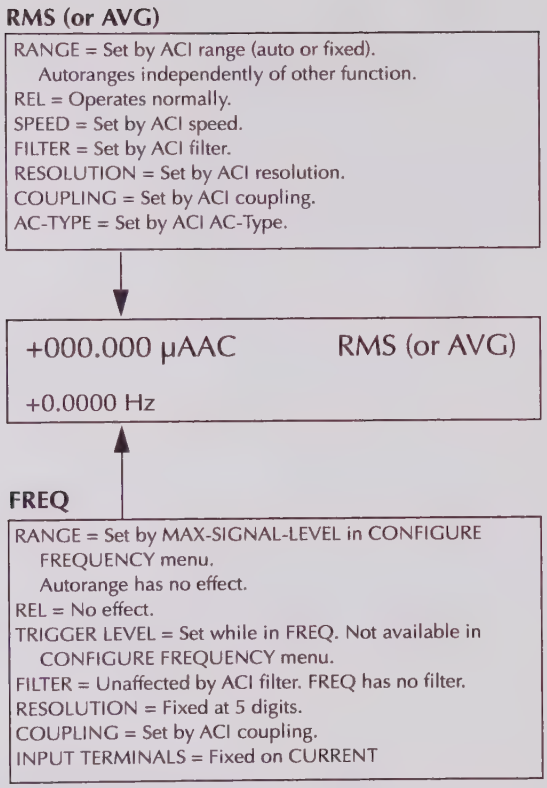
2. Highlight the desired measurement type and press ENTER.

RMS: With this parameter selected, the instrument performs RMS AC current measurements.

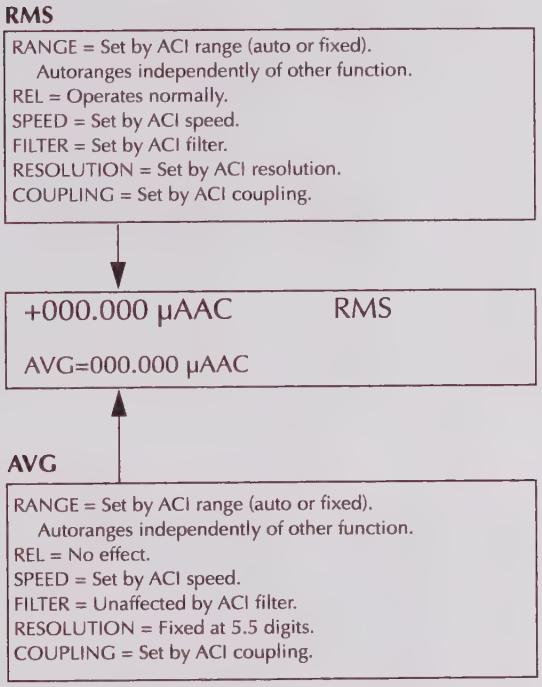
AVERAGE: When this item is selected, the signal path in the instrument bypasses the RMS converter, so the average ACI measurement is just the filtered output of a full wave rectifier.

Multiple displays

The multiple displays for AC current that show multiple functions are shown in Figure 3-13. There are no multifunction displays for DC current.


RMS (or AVG)
RANGE = Set by ACI range (auto or fixed).
Autoranges independently of other function.
REL = Operates normally.
SPEED = Set by ACI speed.
FILTER = Set by ACI filter.
RESOLUTION = Set by ACI resolution.
COUPLING = Set by ACI coupling.
AC-TYPE = Set by ACI AC-Type.
+000.000 µAAC RMS (or AVG)
+0.0000 Hz
FREQ
RANGE = Set by MAX-SIGNAL-LEVEL in CONFIGURE FREQUENCY menu.
Autorange has no effect.
REL = No effect.
TRIGGER LEVEL = Set while in FREQ. Not available in CONFIGURE FREQUENCY menu.
FILTER = Unaffected by ACI filter. FREQ has no filter.
RESOLUTION = Fixed at 5 digits.
COUPLING = Set by ACI coupling.
INPUT TERMINALS = Fixed on CURRENT

A. AC RMS (or average) current and frequency functions


RMS
RANGE = Set by ACI range (auto or fixed).
Autoranges independently of other function.
REL = Operates normally.
SPEED = Set by ACI speed.
FILTER = Set by ACI filter.
RESOLUTION = Set by ACI resolution.
COUPLING = Set by ACI coupling.
+000.000 µAAC RMS
AVG=000.000 µAAC
AVG
RANGE = Set by ACI range (auto or fixed).
Autoranges independently of other function.
REL = No effect.
SPEED = Set by ACI speed.
FILTER = Unaffected by ACI filter.
RESOLUTION = Fixed at 5.5 digits.
COUPLING = Set by ACI coupling.

B. AC RMS and average current functions

Figure 3-13
AC current multifuncton multiple displays

3.4.3 Two and four-wire resistance

2-wire resistance measurements

The Model 2001 can make 2-wire resistance measurements between 1µΩ and 1.05GΩ. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect test leads to the INPUT HI and LO terminals of the Model 2001. Either the front or rear inputs can be used; place the INPUTS button in the appropriate position.
2. Select the Ω2 function.
3. Select a range consistent with the expected resistance. For automatic range selection, press the AUTO key. The AUTO annunciator denotes whether auto-ranging is enabled.
4. Enable offset compensation if needed (refer to the procedure later in this paragraph).

NOTE

Whether or not offset compensation is being used, the 20Ω, 200Ω, 2kΩ, 20kΩ, and 200kΩ ranges require zero correction in order to achieve the best accuracy. The zero correction procedure is located in a following paragraph.

5. Connect the test leads to the resistance as shown in Figure 3-14.

CAUTION

Do not exceed 1100V peak between INPUT HI and LO, or instrument damage may occur.

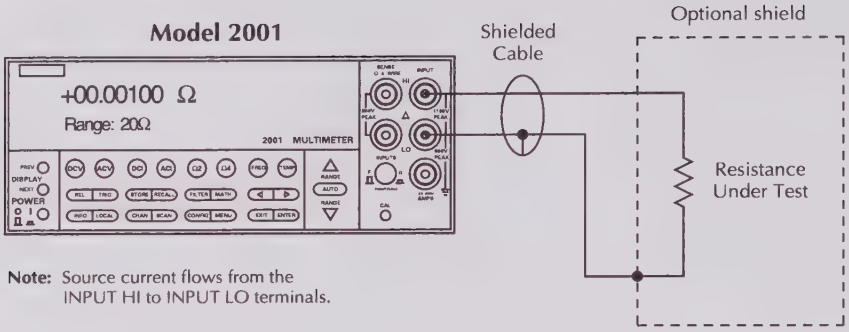


Figure 3-14
Two-wire resistance measurements

6. Observe the display. If the "Overflow" message is shown, select a higher range until a normal reading is displayed. Always use the lowest possible range for the best resolution.
7. Take a reading from the display.

4-wire resistance measurements

The Model 2001 can make 4-wire resistance measurements between 1μΩ and 210kΩ. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect test leads to the INPUT HI and LO and SENSE Ω4 WIRE HI and LO terminals of the Model 2001. Recommended Kelvin test probes include the Keithley Models 5805 and 5806. Either the front or rear inputs can be used; place the INPUTS button in the appropriate position.
2. Select the Ω4 function.
3. Select a range consistent with the expected resistance. For automatic range selection, press the AUTO key. The AUTO annunciator denotes whether auto-ranging is enabled.
4. Enable offset compensation if needed (refer to the procedure later in this paragraph).

NOTE

If offset compensation is not being used, the 20Ω and 200Ω ranges require zero correction in order to achieve the best accuracy. The zero correction procedure is located in a following paragraph.

5. Connect the test leads to the resistance as shown in Figure 3-15.

CAUTION

Do not exceed 1100V peak between INPUT HI and LO, or instrument damage may occur.

6. Observe the display. If the "Overflow" message is shown, select a higher range until a normal reading is displayed. Always use the lowest possible range for the best resolution.
7. Take a reading from the display.

Zeroing

The term "when properly zeroed" means that you must establish a baseline for subsequent measurements on that range. The 20Ω and 200Ω resistance ranges require zero correction to correct for thermal offsets. This procedure should be performed whenever the ambient temperature changes. To zero (rel) the Model 2001, use the following procedure:

1. Disable rel, if presently enabled, by pressing the REL key. The REL annunciator will turn off.
2. Select the desired function (Ω2 or Ω4) and range.
3. Connect the test leads to INPUT HI and LO (and SENSE Ω4 WIRE if the Ω4 function is selected) of the Model 2001 and short them together. Noise and thermal offsets may require a few moments to stabilize.
4. Press the REL key. The display will read zero.
5. Remove the short and connect the test leads to the resistance to be measured.

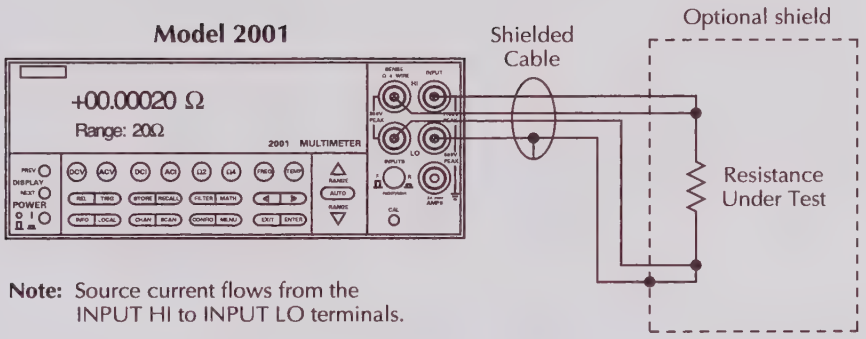


Figure 3-15
Four-wire resistance measurements

Shielding

It helps to shield resistance greater than 100kΩ to achieve a stable reading. Place the resistance in a shielded enclosure and electrically connect the shield to the INPUT LO terminal of the instrument.

Resistance configuration

The following paragraphs detail how to change the Model 2001 from its bench reset conditions for 2-wire and 4-wire resistance measurements. The configuration menus are summarized in Tables 3-16 and 3-17. Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 3-16
CONFIGURE OHMS-2W menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
OFFSETCOMP	Enable/disable offset compensation (20Ω-20kΩ ranges).
MAXAUTORANGE	Set upper limit for autoranging of 2-wire resistance.
1GΩ, 200MΩ, 20MΩ, 2MΩ, 200kΩ, 20kΩ	Select a specific range.

Table 3-17
CONFIGURE OHMS-4W menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz). Select 0.01 PLC.
FAST	Select 0.1 PLC.
MEDIUM	Select 10 PLC.
HIACCURACY	Set integration time in PLC (0.01-10).
SET-SPEED-EXACTLY	Default to setting appropriate for resolution.
SET-BY-RSLN	
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
OFFSETCOMP	Enable/disable offset compensation (20Ω-20kΩ ranges).
MAXAUTORANGE	Set upper limit for autoranging of 4-wire resistance.
200kΩ, 20kΩ, 2kΩ	Select a specific range.

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measured (also known as aperture). It is discussed in paragraph 3.4.1, DC and AC voltage. Only the differences for 2-wire and 4-wire resistance are noted here.

The SET-BY-RSLN parameter optimizes the integration time for the present resolution setting. The defaults for set-by-resolution integration times of Ω2 and Ω4 are listed in Table 3-18.

Table 3-18
Ω2 and Ω4 integration time set-by-resolution

Resolution	Integration time
3.5d, 4.5d	0.01 PLC
5.5d	0.02 PLC
6.5d	0.20 PLC
7.5d	2.00 PLC

Note: If the integration time is SET-BY-RSLN and the resolution AUTO, the integration time will be 1.0 PLC and the resolution 6.5 digits.

FILTER

The FILTER parameter lets you set the digital filter response and control its on/off operation. It is described in paragraph 3.9. Only the specifics for 2- and 4-wire resistance are covered here.

The AUTO parameter for a digital filter optimizes its use for the present measurement function. The defaults for automatic filtering of Ω2 and Ω4 are listed in Table 3-19.

Table 3-19
Ω2 and Ω4 auto filter

Measurement function	State	Type	Reading	Noise tolerance	Averaging Mode
2-wire resistance	On	Advanced	10	1.0%	Moving
4-wire resistance	On	Advanced	10	1.0%	Moving

RESOLUTION

The RESOLUTION parameter sets the display resolution. It is discussed in paragraph 3.4.1, DC and AC voltage. Only the differences for Ω2 and Ω4 are noted here.

The available resolution on all resistance functions and types is 3.5 digits to 7.5 digits. If the Ω2 or Ω4 resolution is AUTO, refer to Table 3-20 for the resolution associated with the integration time.

Table 3-20
Ω2 and Ω4 auto resolution

Integration time	Resolution
0.01 to <0.02 PLC	4.5d
0.02 to <0.20 PLC	5.5d
0.20 to <2.00 PLC	6.5d
2.00 to 10.00 PLC	7.5d

Note: If the resolution is AUTO and the integration time SET-BY-RSLN, the resolution will be 6.5 digits and the integration time 1.0 PLC.

OFFSETCOMP

Offset compensation is used to compensate for voltage potentials, such as thermal offsets, across the device under test. This feature eliminates errors due to a low level external voltage source configured in series with the unknown resistor. Offsets up to ±0.2V on the 20Ω and 200Ω ranges, and from -0.2V to +2V on the 2kΩ and 20kΩ ranges can be corrected with offset compensation. Offset compensation is available for 2- and 4-wire resistance measurements.

During offset compensated resistance measurements, the Model 2001 performs the following steps for each A/D conversion:

1. Makes a normal resistance measurement of the device. In general, this consists of sourcing a current through the device, and measuring the voltage drop across the device.
2. Turns off the internal current source and again measures the voltage drop across the device. This is the voltage caused by an external device.
3. Calculates and displays the corrected resistance value.

Offset compensation not only corrects for small error voltages in the measurement circuit, but it also compensates for thermal voltages generated within the Model 2001. In normal mode ohms, these thermal EMF offsets are accounted for during calibration.

You can enable/disable offset compensation as follows:

1. From the CONFIGURE OHMS-2W or CONFIGURE OHMS-4W menu, select OFFSETCOMP and press ENTER. The following menu is displayed:

   SET OFFSET COMP
   ON OFF

2. Highlight the desired selection and press ENTER.

Offset compensated readings are indicated by "OCmp" to the right of the reading.

Note that the offset compensation settings of the ohms functions are discrete. Thus, enabling offset compensation in 2-wire ohms has no effect on 4-wire ohms.

MAXAUTORANGE

By setting an upper limit on autoranging, you can prevent changes to ranges that you do not want to use. This speeds up the reading rate while still using auto-ranging. You can program the MAXAUTORANGE as follows:

1. From the CONFIGURE OHMS-2W or CONFIGURE OHMS-4W menu, select MAXAUTORANGE and press ENTER. One of the following menus is displayed:

   SET Ω2 MAX AUTORANGE
   1GΩ 200MΩ 20MΩ 2MΩ 200kΩ 20kΩ

or

SET Ω4 MAX AUTORANGE
200kΩ 20kΩ 2kΩ

2. Highlight the desired maximum range for autoranging and press ENTER.

Multiple displays

There are three multiple displays available just for the resistance functions:

- Source current
- Voltage drop
- Lead resistance (Ω4 only)

Source current: This is the value of the current being sourced for the present resistance range. It is based on the calibration constants and is shown as follows:

Source Current = 0.0000 mA

Voltage drop: This display shows the voltage drop across the resistance under test. It is shown as follows:

Voltage Drop = 0.0000 mV

This voltage drop is determined by multiplying the source current by the resistance and does not include voltage contributions from other current that may be flowing through the resistance.

Lead Resistance: This display, available only for 4-wire ohms, shows the value of the lead resistance that is being nulled by using the Ω4 function. You can use the information to decide if a 4-wire measurement is necessary. The display is as follows:

Lead Resistance = 0.0000 Ω

If the lead resistance exceeds 1kΩ, the display is:

Lead Resistance > 1000Ω

3.4.4 Frequency

The Model 2001 can make frequency measurements from 1Hz to 15MHz through its INPUT HI and INPUT LO terminals, and from 1Hz to 1MHz through its AMPS and INPUT LO terminals. Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure is as follows:

1. Connect the test leads to the INPUT HI and LO terminals of the Model 2001. Either the front or rear inputs can be used; place the INPUTS button in the appropriate position.

NOTE

A bench reset defaults the frequency input terminals to INPUT HI and LO.

2. Select the FREQ function.
3. Connect the test leads to the source as shown in Figure 3-16A.

CAUTION

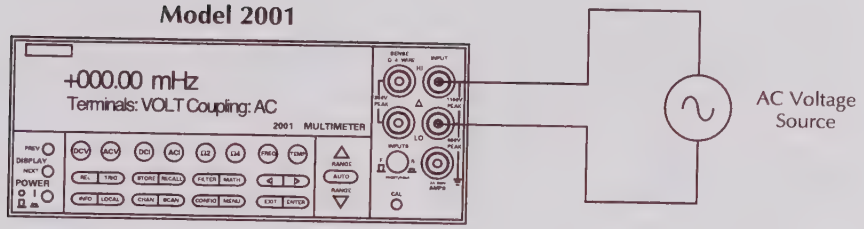
Do not exceed 1100V peak between INPUT HI and INPUT LO, or instrument damage may occur.

4. Take a reading from the display.

The procedure for measuring frequency with the AMPS and INPUT LO terminals is similar. (See Figure 3-16B for a connection diagram.) Be sure the frequency function is configured to use the current terminals.

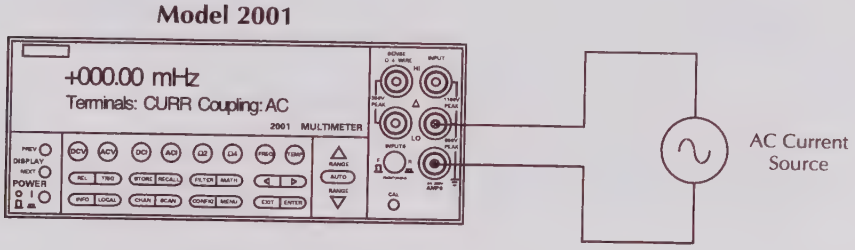
CAUTION

Do not apply more than 2.1A, 250V to the AMPS input, or the amps protection fuse will blow. (Refer to paragraph 3.4.2 for the AMPS fuse replacement procedure.)



Caution : Maximum Input = 1100V peak, 2×10^7 V•Hz

A. AC Voltage Input



Caution : Maximum Input = 1A peak

B. AC Current Input

Figure 3-16
Frequency measurements

Trigger level

The frequency function has an adjustable trigger level. An appropriate trigger level is needed for the frequency counter to operate properly. The instrument only counts cycles with peak amplitudes that reach the trigger level. For example, if the trigger level is set for 5V, cycles with peak amplitudes less than 5V are not counted.

If using AC+DC coupling, make sure the trigger level accounts for the DC bias level. For example, if a 1V peak-to-peak input signal is riding on a 5V DC bias level, a trigger level of 5.5V is appropriate.

While the display is showing frequency measurements, the RANGE ▲ and ▼ keys can be used to change the trigger level of the measurement.

Each press of a RANGE ▲ or ▼ key adjusts the trigger level by 0.5% of the presently selected maximum signal level to a maximum of 60% of the range. The AUTO RANGE key returns the trigger level to 0V or 0mA. After pressing one of the range keys, the present trigger level is momentarily displayed. The trigger level is also available as a multiple display.

See Table 3-21 for the trigger level ranges and increments.

Table 3-21
Trigger level range and increments

Maximum signal level	Trigger level	
	Range	Increment
1V	-0.600 to +0.600V	0.005V
10V	-6.00 to +6.00V	0.05V
100V	-60.0 to +60.0V	0.5V
1000V	-600 to +600V	5V
1mA	-0.600mA to +0.600mA	0.005mA
10mA	-6.00mA to +6.00mA	0.05mA
100mA	-60.0mA to +60.0mA	0.5mA
1A	-600mA to +600mA	5mA

Note: The trigger level for TTL triggering defaults to +0.80V.

Frequency configuration

The following paragraphs detail how to change the Model 2001 from its bench reset conditions for frequency measurements. The configuration menu is summarized in Table 3-22. Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 3-22
CONFIGURE FREQUENCY menu structure

Menu item	Description
MAX-SIGNAL-LEVEL 1V, 10V, 100V, 1000V, TTL 1mA, 10mA, 100mA, 1A	Display maximum signal level menu: Select maximum voltage level for voltage inputs. Select maximum current level for current inputs.
RESOLUTION 4-DIGITS, 5-DIGITS	Display resolution menu: Select a specific resolution.
INPUT-TERMINALS VOLTAGE CURRENT	Input terminals for frequency measurements menu: Select INPUT HI and INPUT LO terminals. Select AMPS and INPUT LO terminals.
COUPLING AC AC+DC	Coupling menu: Select AC coupled measurements. Select DC coupled measurements.

Note: The maximum signal level menu is coupled to the input terminals menu, i.e., voltage levels are shown if voltage is the selected input.

MAX-SIGNAL-LEVEL

The maximum signal level is used to specify the maximum expected input voltage or current level for frequency measurements. The maximum signal level is set as follows:

1. From the CONFIGURE FREQUENCY menu, select MAX-SIGNAL-LEVEL and press ENTER. Depending on the presently selected input terminals (VOLTAGE or CURRENT), one of the following menus is displayed:

   MAXIMUM SIGNAL LEVEL
   1V 10V 100V 1000V TTL

   or

   MAXIMUM SIGNAL LEVEL
   1mA 10mA 100mA 1A

2. Highlight the desired maximum signal level and press ENTER. Selecting the TTL parameter configures the maximum signal level to 10V and the trigger level to +0.80V.

RESOLUTION

The available display resolutions are 4 digits and 5 digits. There is no auto resolution parameter on the frequency function.

You can set the resolution as follows:

1. From the CONFIGURE FREQUENCY menu, select RESOLUTION and press ENTER. The following menu is displayed:

   SET FREQ RESOLUTION
   4-DIGITS 5-DIGITS

2. Highlight the desired resolution and press ENTER.

INPUT-TERMINALS

Both the volts and amps input terminals can be used to measure frequency. The upper limit on the voltage terminals is 15MHz; on the amps terminals it is 1MHz. The voltage limit is subject to the 2×10^7V•Hz product.

The input terminals for frequency measuring are set as follows:

1. From the CONFIGURE FREQUENCY menu, select INPUT-TERMINALS and press ENTER. The following menu is shown:

   FREQ INPUT SOURCE
   VOLTAGE CURRENT

2. Highlight the desired input source and press ENTER.

COUPLING

This parameter selects the input coupling for the frequency function. When AC coupling is selected, a DC blocking capacitor is placed in series with the input. This removes the DC component of the input signal.

When AC+DC coupling is selected, the blocking capacitor is removed. Subsequent frequency measurements will reflect both the AC and DC components of the signal.

You can set the frequency coupling as follows:

1. From the CONFIGURE FREQUENCY menu, select COUPLING and press ENTER. The following menu is displayed:

   SET FREQ COUPLING
   AC AC+DC

2. Highlight the desired coupling and press ENTER.

Multiple displays

There are two multiple displays just for the frequency function:

- Period calculation
- Trigger level

The multiple display showing the period of the waveform is calculated from the frequency measurement and, as such, is only available when the frequency does not equal 0Hz. It is also unavailable when math is enabled.

The trigger level multiple display is the same message that is displayed when the trigger level is changed, but it is a permanent display.

3.4.5 Temperature

The Model 2001 measures temperature with two different sensor types: RTDs and thermocouples. With RTDs, the Model 2001 can measure temperature between -200°C and +630°C. RTDs can be connected to the input terminals or the optional Model 2001-SCAN scanner card.

With thermocouples connected to an external thermocouple card, such as a Model 7057A or 7402 in a Model 7001 Switch System, the instrument measures temperature over a range that is dependent on the thermocouple type. (Refer to the specifications in Appendix A.)

Temperature measurements

Assuming "bench reset" conditions (see paragraph 3.12.1), the basic procedure to measure temperature with a type PT385 4-wire RTD (the default sensor) is as follows:

1. Connect the RTD sensor to the Model 2001 as shown in Figure 3-17. You can use banana plugs (with the front or rear inputs), or the optional Model 8680 RTD Probe Adapter (with the front inputs). Place the INPUTS button in the appropriate position. RTDs can also be connected to the optional Model 2001-SCAN scanner card. (See the Model 2001-SCAN manual.)
2. Select the TEMP function.

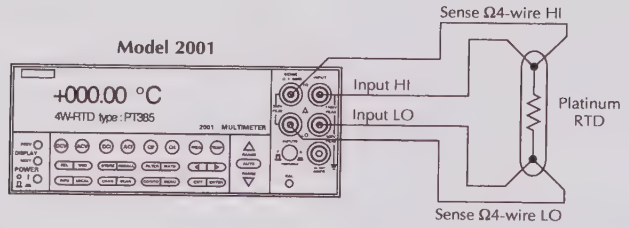
CAUTION

Do not exceed 1100V peak between INPUT HI and LO, or 350V peak between SENSE Ω4 WIRE HI and LO, or instrument damage may occur.

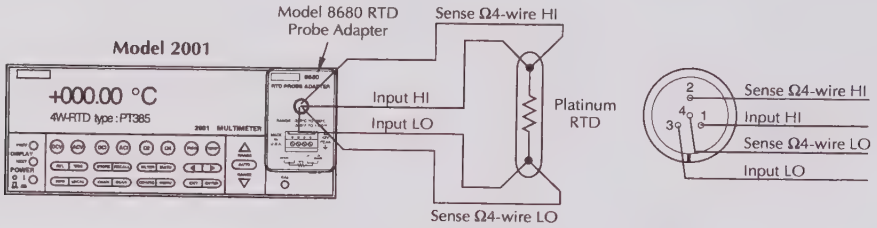
3. Observe the display. If the "Overflow" message is shown, the RTD might not be connected properly.
4. Take a reading from the display.

The procedure for measuring temperature with 3-wire and 2-wire RTDs is similar. (See Figures 3-18 and 3-19 for connection diagrams.) Be sure that the temperature function is configured for the correct sensor type. (Use the 4-WIRE-RTD selection for a 3-wire RTD sensor.)

To measure temperature with thermocouples, you need to connect the thermocouples to a suitable external scanner card, such as the Keithley Model 7057A or 7402. These cards must be inserted into a Model 705 or 706 Scanner or the Model 7001 Switch System, as shown in Figure 3-20. The thermocouple cards use Channel 1 as the reference junction, and must be configured on the Model 2001 for voltage reference and offset.

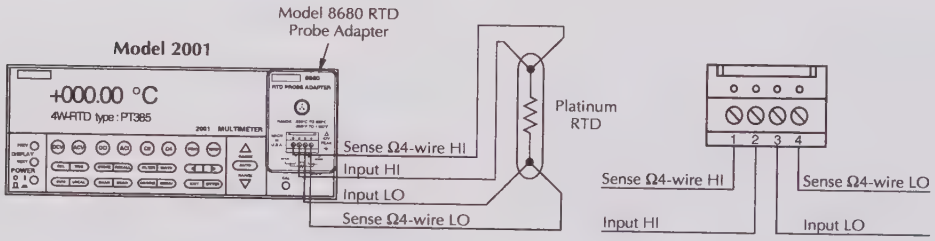


A. Connections to Banana Jacks



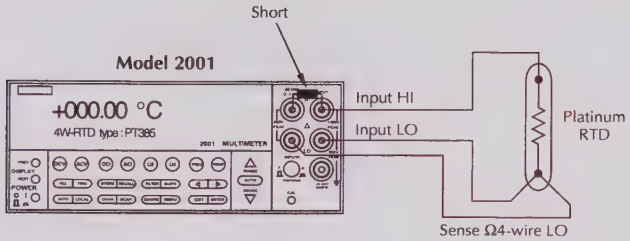
WARNING: To avoid a shock hazard and possible instrument damage, do not use the Model 8680 RTD Probe Adapter to measure voltages exceeding 30V RMS, 42.4V peak.

B. Connections to Circular Jack

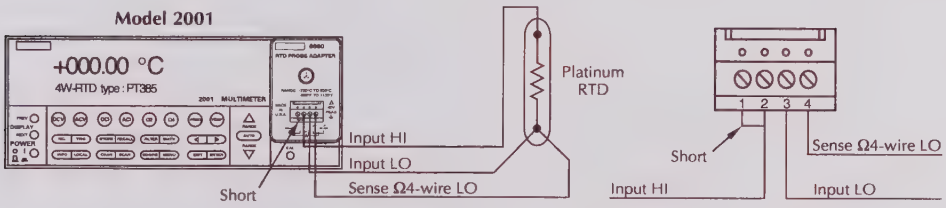


C. Connections to Terminal Block

Figure 3-17
4-wire RTD temperature measurements



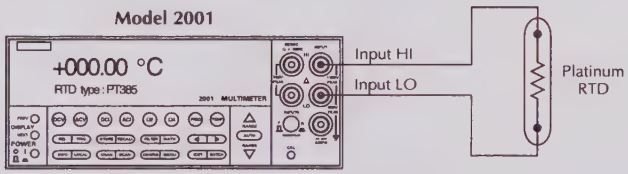
A. Connections to Banana Jacks



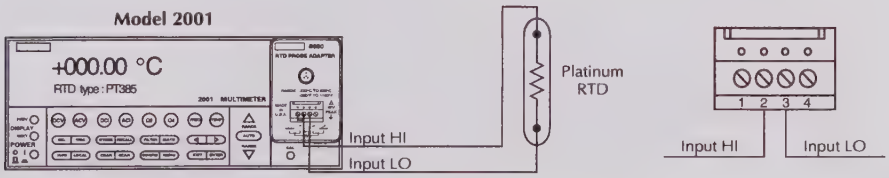
B. Connections to Terminal Block

WARNING : To avoid a shock hazard and possible instrument damage, do not use the Model 8680 RTD Probe Adapter to measure voltages exceeding 30V RMS, 42.4V peak.

Figure 3-18
3-wire RTD temperature measurements



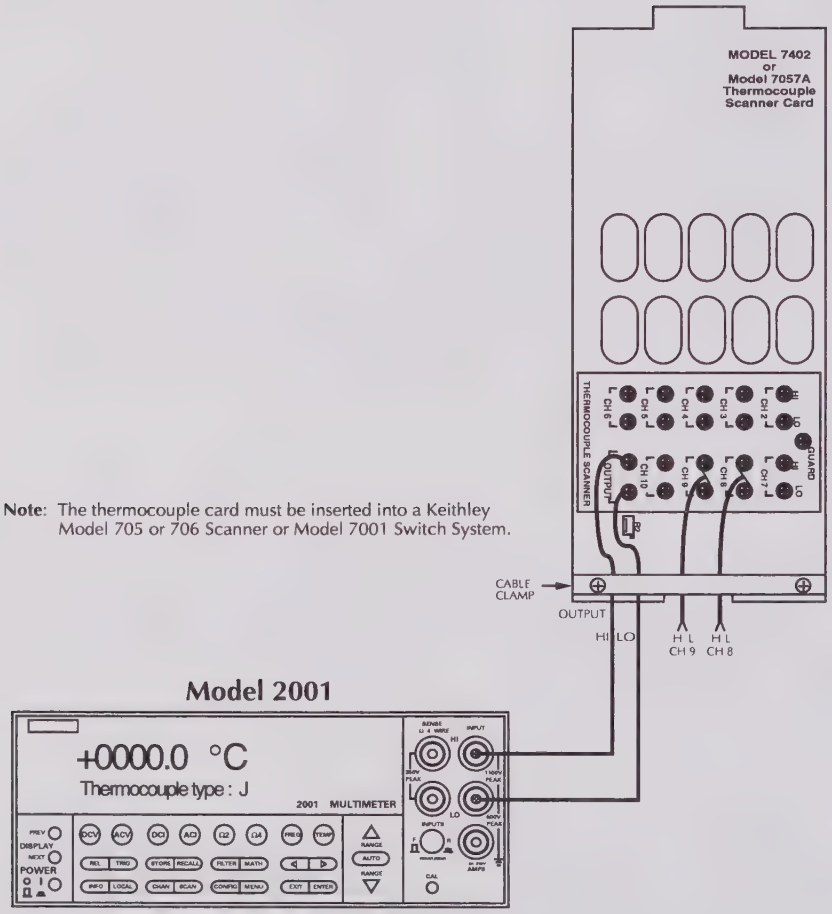
A. Connections to Banana Jacks



B. Connections to Terminal Block

WARNING : To avoid a shock hazard and possible instrument damage, do not use the Model 8680 RTD Probe Adapter to measure voltages exceeding 30V RMS, 42.4V peak.

Figure 3-19
2-wire RTD temperature measurements



Note: The thermocouple card must be inserted into a Keithley Model 705 or 706 Scanner or Model 7001 Switch System.

Figure 3-20
Thermocouple configuration

Temperature configuration

The following paragraphs detail how to change the Model 2001 from its bench reset conditions for temperature measurements. The configuration menu is summarized in Table 3-23. Note that a function does not have to be selected in order to be configured. When the function is selected, it will assume the programmed status.

Table 3-23
CONFIG TEMPERATURE menu structure

Menu item	Description
SENSOR	Sensor type menu:
4-WIRE-RTD	4-wire RTD type menu:
PT385	Select a PT385 type.
PT3916	Select a PT3916 type.
USER-RTD	Select desired R-zero, alpha, beta, and delta.
SPRTD	Select SPRTD type.
RTD	2-wire RTD type menu:
PT385	Select a PT385 type.
PT3916	Select a PT3916 type.
USER-RTD	Select desired R-zero, alpha, beta, and delta.
SPRTD	Select SPRTD type.
THERMOCOUPLE	Thermocouple setup menu:
THERMOCOUPLE-TYPE	Select desired thermocouple type (J, K, T, E, R, S, B, N).
REF-JUNCTIONS	Configure reference junction menu (JN1 thru JN5):
CONFIGURE	Configure simulated or real junction.
ACQUIRE-REF-TEMP	Acquire reference temperature.
UNITS	Temperature units menu:
DEG-C, DEG-F, K	Select desired temperature units.
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Select simple average filter (1-100 readings).
AVERAGING-MODE	Select moving average or repeating average mode.
RESLN	Display resolution menu:
AUTO	Default to resolution appropriate for sensor.
1°, 0.1°, 0.01°, 0.001°	Select a specific resolution.

SENSOR

This parameter is used to select the temperature sensor. If using a 4- or 3-wire RTD sensor, choose 4-WIRE-RTD. If using a 2-wire RTD, choose RTD. Select THERMOCOUPLE when using an external thermocouple scanner card (Model 7057A or Model 7402).

You can select the temperature sensor as follows:

1. From the CONFIG TEMPERATURE menu, highlight SENSOR and press ENTER. The following menu is displayed:

   TEMP SENSOR TYPE
   4-WIRE-RTD RTD THERMOCOUPLE

2. Use the cursor keys to highlight the desired sensor and press ENTER. For the 4-WIRE-RTD and RTD parameters, the following menu is displayed:

   SET RTD TYPE
   PT385 PT3916 USER-RTD SPRTD

Choosing THERMOCOUPLE displays the following menu:

THERMOCOUPLE SETUP
THERMOCOUPLE-TYPE REF-JUNCTIONS

RTD type: This menu has three options for RTD standards. Two are configured for common RTDs, the third allows you to enter your own RTD factors:

- PT385–Selects default parameters for 0.00385 standard.
- PT3916–Selects default parameters for 0.003916 standard.
- USER-RTD–Selects user-defined parameters.

When a PT385 or PT3916 is selected, the instrument uses the following defaults:

Type	Alpha	Beta	Delta	Ω at 0°C
PT385	0.003850	0.111	1.50700	100Ω
PT3916	0.003916	0.116	1.50594	100Ω

If you want to change one or more of these factors, select USER-RTD, and enter the desired values. The equations using the factors are shown in Figure 3-21.

For T < 0°C:

$$R_T = R_0[1 + AT + BT^2 + CT^3(T\text{-}100)]$$

For 0°C < T < 630°C:

$$R_T = R_0(1 + AT + BT^2)$$

Where:

$$A = \alpha\left(1 + \frac{\delta}{100}\right)$$

$$B = -\alpha\delta \bullet 10^{-4}$$

$$C = -\alpha\beta \bullet 10^{-8}$$

Above 0°C, the equation solves faster by applying:

$$T = \frac{-A + \sqrt{A^2 - 4B\left(1 - \frac{R_T}{R_0}\right)}}{2B}$$

Below 0°C, it is an iterative solution and it runs slower.

Figure 3-21
Temperature equations

SPRTD: Choosing type SPRTD takes you to the SPRTD COEFFICIENTS menu, which allows you to program the following parameters:

R-ZERO: RTD 0°C resistance value
A4: set A4 coefficient
B4: set B4 coefficient
A7: set A7 coefficient
B7: set B7 coefficient
C7: set C7 coefficient

The ITS-90 standard provides two reference equations for Standard Platinum Resistance Thermometers covering the temperature range 18.8033K to 1234.93K. A single SPRTD, however, usually cannot be used to cover the entire range.The temperature range is therefore broken up into several subranges. These subranges depend on the calibration points of the temperature scale and are based on the melting or triple points of various pure substances. For an exact list

Table 3-24
Translating SPRTD coefficients

Coefficients	RTD coefficients to Model 2001 coefficients
Subrange #1: 13.8033K - 273.16K	Not applicable
Subrange #2: 24.5561K - 273.16K	A2 to A4, B2 to B4
Subrange #3: 54.3584K - 273.16K	A3 to A4, B3 to B4
Subrange #4: 83.8058K - 273.16K	No substitution needed
Subrange #5: 234.3156K - 302.9146K	A5 to A4, A5 to A7, B5 to B4 B5 to B7, Set C7 = 0. A5 value entered for both A4 and A7; B5 value entered for both B4 and B7
Subrange #6: 273.15K - 1234.93K	Not applicable
Subrange #7: 273.15K - 933.473K	No substitution needed
Subrange #8: 273.15K - 692.677K	A8 to A7, B8 to B7, Set C7 = 0
Subrange #9: 273.15K - 505.078K	A9 to A7, B9 to B7, Set C7 = 0
Subrange #10: 273.15K - 429.7485K	A10 to A7, B10 to B7, Set C7 = 0
Subrange #11: 273.15K - 302.9146K	A11 to A7, Set B7 = 0, C7 = 0

of the elements needed and details on RTD calibration, refer to NIST Technical Note 1265 "Guidelines For Realizing the International Temperature Scale of 1990". In each subrange, the calibration constants required for that range are listed.

An SPRTD as supplied from the manufacturer will come with a certificate of calibration that lists the calibration constants and the temperature range supported. In all cases except subranges #4 and #7, translation of the supplied coefficients to Model 2001 values will be required. In most cases, this translation is done simply entering the A value (for example) supplied with the SPRTD into the A4 position (temperatures less than 0°C) or A7 value (temperatures above 0°C) required by the Model 2001. The same procedure is used for translating the B and, where applicable, C constants.

Table 3-24 should be helpful in translating SPRTD coefficients to Model 2001 SPRTD coefficients. The Model 2001 supports SPRTD temperatures between 83.805K and 933.473K. For any of the subranges below, only temperatures within the range from 83.805K to 933.47K will be measured.

Measurement Example: Suppose you are using an SPRTD that has been calibrated for subrange #2 above, in which case the RTD is calibrated for measurements between 24.5561 and 273.16K. The Model 2001, however, supports only SPRTD temperatures down to 83.805K, so temperatures below this value will be reported as an overflow even though the SPRTD is capable of measuring lower. The calibration certificate lists A2, B2, C1, C2, and C3 as the calibration coefficients. You can set up the Model 2001 for this measurement as follows:

1. Set the temperature sensor type to be FRTD (4-wire measurement) from the CONFIG/TEMP/SENSOR/TYPE menu.
2. Choose the SPRTD RTD type using the CONFIG/TEMP/SENSOR/TYPE/FRTD/SPRTD menu.
3. From the SPRTD COEFFICIENTS menu, set the RTD 0°C resistance value and the following coefficients:
   - Set the Model 2001 A4 coefficient to the RTD certificate A2 value.
   - Set the Model 2001 B4 coefficient to the RTD certificate B2 value.

Note that the A7, B7, and C7 values will not be used for this sensor.

4. Switch to the temperature function, and begin taking readings.

THERMOCOUPLE TYPE: This option of the THERMOCOUPLE SETUP menu brings up a menu of thermocouple types:

```
THERMOCOUPLE TYPE
J  K  T  E  R  S  B  N
```

To select a type, highlight it and press ENTER.

REF-JUNCTIONS: This item of the THERMOCOUPLE SETUP menu allows you to select one of five reference junctions for further configuration. Typically, each thermocouple card uses a single reference junction. The menu is displayed as follows:

```
CONFIGURE REFJCNS
JCN1  JCN2  JCN3  JCN4  JCN5
```

After choosing one of the reference junctions, you can configure it further or acquire a reference temperature (to update the stored reference temperature), as shown in the typical following menu:

```
REFERENCE JUNCTION#1
CONFIGURE  ACQUIRE-REF-TEMP
```

Choosing the ACQUIRE-REF-TEMP option updates the stored reference temperature used for generating a temperature measurement. If the junction type (JCN) is simulated, the defined simulated junction temperature is used. If the junction type is real, you must manually close that channel from the scanner before acquiring the temperature.

Selecting the CONFIGURE option displays a configuration menu for a particular reference junction (#1 through #5):

```
CONFIGURE REFJCN#1
SIMULATED-TEMP  REAL-JUNCTION
```

The SIMULATED-TEMP option allows you to enter a default temperature. Typical reference junction temperatures are 0°C and 23°C. (Note the reference junction temperature is shown in the units selected by the SET TEMP UNITS menu.) The REAL-JUNCTION option lets you enter values for a temperature coefficient for the selected reference junction (in mV/°C) and an offset voltage (in mV at 0°C). Consult the Model 7057A or 7402 manual for correct configuration.

UNITS

This parameter selects the displayed units for temperature measurements. You can program the temperature units parameter as follows:

1. From the CONFIG TEMPERATURE menu, select UNITS and press ENTER. The following menu is displayed:

```
SET TEMP UNITS
DEG-C  DEG-F  K
```

2. Highlight the desired units and press ENTER.

There is a multiple display for the temperature function that shows the reading expressed in all three temperature units.

SPEED

The SPEED parameter sets the integration time of the A/D converter, the period of time the input signal is measured (also known as aperture). It is discussed in paragraph 3.4.1, DC and AC voltage. Only the differences for temperature are noted here.

The SET-BY-RSLN parameter optimizes the integration time for the present resolution setting. The defaults for set-by-resolution integration times of temperature are listed in Table 3-25.

Table 3-25
Temperature integration time set-by-resolution

Resolution degrees	Resolution digits	Integration time
1 degree	3.5d	1.0 PLC
0.1 degree	4.5d	1.0 PLC
0.01 degree	5.5d	1.0 PLC
0.001 degree	6.5d	1.0 PLC

Note: If the integration time is SET-BY-RSLN and the resolution AUTO, the integration time will be 1.0 PLC and the resolution set by sensor.

FILTER

The FILTER parameter lets you set the digital filter response and control its on/off operation. It is described in paragraph 3.9. Only the specifics for temperature are covered here.

The advanced filter is not available for the temperature function.

The AUTO parameter for a digital filter optimizes its use for the present measurement function. The defaults for automatic filtering of temperature are as follows:

State	Type	Readings	Averaging Mode
On	Averaging	10	Moving

RESLN

The RESLN parameter sets the display resolution. It is discussed in paragraph 3.4.1, DC and AC voltage. Only the differences for temperature are noted here.

Resolution for temperature is not expressed in number of digits, but in fractions of a degree, ranging from 1° to 0.001°. The accuracy of RTD and thermocouple measurements are rated at different resolutions; refer to the specifications in Appendix A for details.

If the temperature resolution is AUTO, the resolution is forced to match the sensor type. Refer to Table 3-26 for the resolution associated with the various sensors.

Table 3-26
Temperature auto resolution

Sensor	Resolution	
	Degree	Digits
RTDs 2-, 3-, or 4-wire	0.01	5.5d
Thermocouples J, K, T, E	0.1	4.5d
Thermocouples R, S, B, N	1	3.5d

Note: If the resolution is AUTO and the integration time SET-BY-RSLN, the integration time will be 1.0 PLC.

Multiple displays

The available multiple displays for temperature depend on the presently selected sensor type, except for the multiple display that shows temperature in three different units:

```
+0000.0 °C
+0000.0 °F   +0000.0 K
```

RTD measurements have a multiple display for the resistance of the RTD, such as:

```
RTD Resistance = +0.0000 Ω
```

Thermocouple measurements have multiple displays for the thermocouple voltage and reference junction temperature. Sample displays are:

```
Thermocouple Voltage = 0.0000mV
Reference junction = 00.0 °C
```

Note that the reference junction temperature is shown in the units selected by the SET TEMP UNITS menu. The display of two blinking question marks at the right of the reference junction temperature indicates an overflow of the reference junction measurement. Thermocouple measurements will be made normally using the existing reference temperature value.

3.5 Range

The selected measurement range affects both the ultimate resolution and accuracy of the measurements as well as the maximum signal that can be measured. The range setting (fixed or auto) for each measurement function is saved when changing functions.

The following paragraphs discuss range resolution and manual and auto-range operation.

3.5.1 Display resolution

The display resolution of a Model 2001 reading depends on the selected range and the resolution setting. The default and maximum display resolutions for every range on each function are included in the specifications of Appendix A.

You can set the display resolution, as described in paragraph 3.4.

3.5.2 Maximum readings

The full scale readings for every range on each function are included in the specifications of Appendix A. Input values more than the maximum reading listed cause the "Overflow" message to be displayed.

3.5.3 Manual ranging

To select a manual range, simply press the RANGE ▲ or RANGE ▼ key. The instrument changes one range per key press. The selected range is displayed on the bottom line of the display, such as:

```
+000.0094 mVDC
Range: 200 mVDC
```

Once the highest or lowest range has been selected, pressing the corresponding key has no further effect, except for the display of a momentary informational message, for example:

```
Range at maximum: 1000 VDC
```

If the instrument displays the "Overflow" message on a particular range, select a higher range until an on-range reading is displayed. Use the lowest range possible without causing an overflow to ensure best accuracy and resolution.

Note that the frequency and temperature functions have just one range. For the frequency functions, the RANGE ▲ and ▼ keys increase and decrease the trigger level by 0.5%. On temperature the keys have no effect.

3.5.4 Autoranging

To enable autoranging, press the AUTO key. The AUTO annunciator turns on when autoranging is selected. While autoranging is selected, the instrument automatically chooses the best range to measure the applied signal.

NOTE

Autoranging should not be used when optimum speed is required. Autoranging speeds are covered in the specifications of Appendix A.

Note that up-ranging occurs at 105% of range, while down-ranging occurs at 10% of range.

To cancel autoranging, press AUTO or the RANGE ▲ or ▼ key. Pressing AUTO to cancel autoranging leaves the instrument on the present range.

Pressing the RANGE ▼ key when the instrument has autoranged to the lowest range displays the following momentary typical message and leaves the instrument in autorange:

Range at minimum: 200 mVDC

The instrument operates similarly if the RANGE ▲ key is pressed when the instrument has autoranged to the highest range.

For the frequency function, pressing the AUTO key returns the trigger level to 0.0V. The AUTO key has no effect for the temperature function.

3.6 Relative

The rel (relative) operation subtracts a reference value from actual readings. When rel is enabled by the REL key, the instrument uses the present reading as a relative value. Subsequent readings will be the difference between the actual input value and the rel value. You can also enter and enable a relative value from the CONFIG-REL display.

A rel value can be established for each measurement function. For example, a 10μA reference can be set for DC current measurements, and a 100Ω reference for 2-wire resistance. The state and value of rel for each measurement function are saved when changing functions.

Once a rel value is established for a measurement function, the value is the same for all ranges. For example, if 100μA is set as a rel value on the 200μA range, then the rel is also 100μA on the 2mA, 20mA, 200mA, and 2A ranges. Similarly, if 150V is set as a rel value on the 200V range, the rel is also 150V on the 1000V, 20V, 2V, and 200mV ranges.

A relative value can be as large as the highest range for the particular function. Table 3-27 lists the allowable range of rel values for each function.

Selecting a range that cannot accommodate the rel value does not cause an overflow condition, but it also does not increase the maximum allowable input for that range. For example, on the 2mA range, the Model 2001 still overflows for a 2.1mA input.

Table 3-27
Allowable rel values

Function	Rel range	
DC voltage	-1.1e3 to +1.1e3	(±1100V)
AC voltage	-7.75e2 to +7.75e2	(±775V)
DC current	-1.2e1 to +1.2e1	(±12A)
AC current	-2.1e0 to +2.1e0	(±2.1A)
2-wire resistance	0 to +1.05e9	(0 to 1.05GΩ)
4-wire resistance	0 to +2.1e5	(0 to 210kΩ)
Frequency	0 to +1.5e7	(0 to 15MHz)
Temperature	-3.28e2 to +3.31e3	(-328 to +3310°)

3.6.1 Configuring rel

From the CONFIG-REL display, you can view or change the rel value for the present measurement function. To view or change the rel value of a different function, you must first select it by pressing the appropriate function key.

Press the CONFIG key, and then the REL key to access the following display:

RELVAL=+0.000000e+00

Use the cursor (◄ and ►) and RANGE keys to move among the digits and set their desired values. If the value is too large for the present measurement function, the following typical message is displayed when you press ENTER:

MAXIMUM ALLOWED VAL:
1.100000e+03

and rel is not enabled. If the value is within the limits shown in Table 3-27, you are returned to the normal reading display with that value of rel already enabled.

Previously stored rel values are converted if temperature or AC voltage units are changed. For example, a rel value of 100 that was stored with units of DEG-C is converted to 212 if temperature units are changed to DEG-F.

Note that a bench or GPIB reset clears any stored rel values and disables rel for all functions.

3.6.2 Enabling rel

From the normal reading display, the REL key toggles the rel operation on and off. The present state is indicated by the REL annunciator. Each time rel is enabled by the REL key, the present reading becomes the new rel value for that function. You cannot rel an overflow reading.

To make a new reading the rel value, rel must first be disabled and then enabled again. Disabling rel does not clear any stored rel value.

The present rel value for each measurement function can be viewed from the CONFIG-REL display, as described in paragraph 3.6.1.

When rel is enabled, the resulting reading is the algebraic difference between the actual input value and the rel value:

rel'd reading = actual value - relative value

With percent or mX+b math enabled, the rel'd reading is acted on by the math operation:

displayed reading = math operation (rel'd reading)

A rel value expressed in dB or dBm is applied after the reading is referenced to the selected level.

3.6.3 Multiple display of rel

One of the "multiple displays" allows you to view the reading without rel applied on the bottom line of the display and the rel'd reading on the top line. The display is available by repeatedly pressing either the NEXT or PREVious DISPLAY key to scroll through the multiple displays of the particular function. The following is a typical message for a rel multiple display:

```
+000.012 mVAC RMS
Actual=+001.012 (without REL)
```

3.7 Triggers

The following paragraphs discuss front panel triggering, trigger configuration, and external triggering, including example setups.

Model 2001 triggers are set up in the CONFIGURE TRIGGER menu. The menu structure is shown and summarized in Table 3-28. Some general rules to navigate menus are given in paragraph 3.3.

3.7.1 Trigger model

The following information describes triggering of the Model 2001 from the front panel. The flowchart of Figure 3-22 summarizes front panel triggering. It is called the Trigger Model because it is patterned after the SCPI commands sent over the IEEE-488 bus to control triggering.

Table 3-28
CONFIGURE TRIGGER menu structure

Menu item	Description
MEASURE	Measure layer menu:
SOURCE	Select measure source:
IMMEDIATE	Use to make measurements immediately.
EXTERNAL	Use external triggers to control measuring.
MANUAL	Use TRIG key to control measuring.
GPIB	Use bus triggers to control measuring.
TRIGLINK	Use Trigger Link triggers to control measuring. Enter Trigger Link mode and lines.
TIMER	Use a timer to control measuring and enter interva between triggers (0.001-999999.999sec.).
HOLD	Use to hold up the measurement in the measure layer.
DELAY	Use to delay measurement in the measure layer (0.001-999999.999sec.).
COUNT	Define number of measurements to make:
INFINITE	Repeat measuring indefinitely.
ENTER-CHAN-COUNT	Count = use defined value (1-99999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
SCAN	Scan layer menu:
SOURCE	Select scan source:
IMMEDIATE	Use to pass operation immediately into the measure layer.
EXTERNAL	Use external triggers to control scanning.
MANUAL	Use TRIG key to control scanning.
GPIB	Use bus triggers to control scanning.
TRIGLINK	Use Trigger Link triggers to control scanning. Enter Trigger Link lines.
TIMER	Use a timer to control scanning and enter interval between scans (0.001-999999.999sec.).
HOLD	Use to hold up the measurement in the scan layer.
DELAY	Use to delay scan in the scan layer (0.001-999999.999sec.).
COUNT	Define number of scans to be performed:
INFINITE	Repeat scanning indefinitely.
ENTER-SCAN-COUNT	Count = user defined value (1-99999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
ARM	Arm layer menu:
SOURCE	Select arm source:
IMMEDIATE	Use to arm meter immediately and pass operation into the scan layer.
EXTERNAL	Use external triggers to arm meter.
MANUAL	Use TRIG key to arm meter.
GPIB	Use bus triggers to arm meter.
TRIGLINK	Use Trigger Link triggers to arm meter. Enter Trigger Lin lines.
HOLD	Use to hold up the measurement in the arm layer.
COUNT	Define number of times to arm meter:
INFINITE	Continuously re-arm meter.
ENTER-ARM-COUNT	User defined count value (1-99999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
HALT	Use to halt triggers. Press TRIG key to resume triggering.

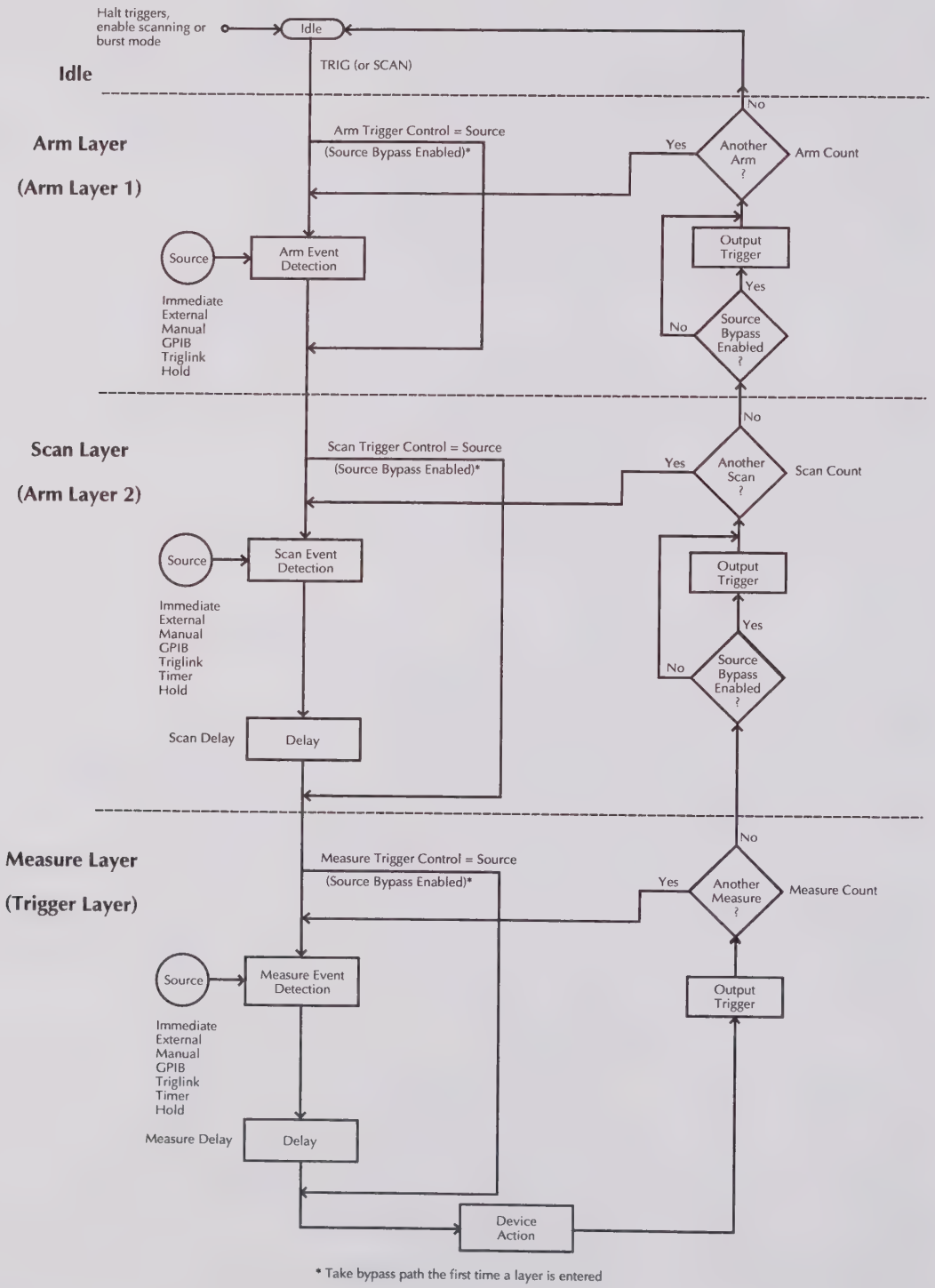


Figure 3-22
Trigger model (front panel operation)

Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the three layers of the Trigger Model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform any measurement or scanning functions.

From the front panel there are four ways to put the instrument into idle:

- Select RESET GPIB from the SAVESETUP option of the main menu. Press the TRIG key to take a reading. After each reading, the instrument returns to the idle state.
- Select HALT from the CONFIGURE TRIGGER menu. Press the TRIG key to resume triggering.
- Enable BURST-MODE from the CONFIGURE DATA STORE menu. This places the instrument in idle until the TRIG key is pressed. After each burst acquisition the instrument returns to idle.
- Configure an internal or external scan with the SCAN key. Disabling the scan resumes triggering.

Once the instrument is taken out of the idle state, operation proceeds into the arm layer (arm layer 1) of the Trigger Model.

Arm layer

NOTE

For bus operation, this layer is called arm layer 1.

In general, the instrument requires an arm event to allow operation to proceed to the next layer (scan layer). With an arm source of Immediate, operation proceeds to the next layer when the instrument is taken out of the idle state. Selecting BENCH or GPIB RESET from the SAVESETUP option of the main menu also sets the arm source to Immediate. With one of the other sources selected, the instrument waits until the appropriate event occurs:

- With the External source selected, the instrument waits for an input trigger via EXTERNAL TRIGGER on the rear panel.
- With the Manual source selected, the instrument waits until the front panel TRIG key is pressed.
- With the GPIB source selected, the instrument waits for a bus trigger (GET or *TRG).
- With the Trigger Link source selected, the instrument waits for an input trigger via TRIGGER LINK on the rear panel.
- With the HOLD source selected, the instrument does not respond to any of the event sources.

As can be seen in the flowchart, there is a path that allows operation to loop around the source. When Source Bypass is enabled (Arm Trigger Control set to Source) and the event source is External or Trigger Link, operation loops around the source on the initial pass through the arm layer. If programmed for another arm (arm count > 1), the bypass loop is not in effect even though it is still enabled. The Source Bypass loop resets (is in effect) if operation goes into Idle.

Enabling Source Bypass also enables the Output Trigger. When operation returns to the arm layer from the scan layer, an output trigger pulse occurs. If the event source is Trigger Link, an output trigger pulse is available on the programmed TRIGGER LINK output line. For all other event sources, the output trigger pulse is available at the METER COMPLETE connector. The Output Trigger in this layer is disabled when Source Bypass is disabled (Arm Trigger Control set to Acceptor).

After all other instrument operations are complete, the instrument can be returned to the arm layer by programming the instrument for additional arms. The Arm Count option is used to set the arm count to a finite value (where n = 1 to 99999) or for an infinite number of arms. Selecting BENCH or GPIB RESET from the SAVESETUP option of the main menu sets the arm count to one.

After the instrument leaves the arm layer, operation proceeds into the scan layer (arm layer 2).

Scan layer

NOTE

For bus operation, this layer is called arm layer 2.

In general, the instrument requires a scan event to allow operation to proceed to the next layer (measure layer). With a scan source of Immediate, operation immediately proceeds to the next layer. Selecting BENCH or GPIB RESET from the SAVESETUP option of the main menu also sets the scan source to Immediate. With one of the other sources selected, the instrument waits until the appropriate event occurs:

- With the External source selected, the instrument waits for an input trigger via EXTERNAL TRIGGER on the rear panel.

- With the Manual source selected, the instrument waits until the front panel TRIG key is pressed.
- With the GPIB source selected, the instrument waits for a bus trigger (GET or *TRG).
- With the Trigger Link source selected, the instrument waits for an input trigger via TRIGGER LINK on the rear panel.
- With the Timer source selected, operation immediately proceeds into the measure layer on the initial pass through the scan layer. Each additional scan does not occur until the programmed timer interval elapses. The timer can be set from 1msec to 999999.999sec.
- With the HOLD source selected, the instrument does not respond to any of the event sources.

After the programmed scan event is detected, the instrument waits for the programmed Delay to time out. The scan layer Delay can be set from 0 to 999999.999sec. Selecting BENCH or GPIB RESET from the SAVESETUP option of the main menu sets the Delay to zero seconds.

As can be seen in the flowchart, there is a path that allows operation to loop around the source. When Source Bypass is enabled (Scan Trigger Control set to Source) and the event source is External or Trigger Link, operation loops around the source on the initial pass through the scan layer. If programmed for another scan (scan count > 1), the bypass loop is not in effect even though it is still enabled. The Source Bypass loop resets (is in effect) if operation goes back into the arm layer.

Enabling Source Bypass also enables the Output Trigger. When operation returns to the scan layer from the measure layer, an output trigger pulse occurs. If the event source is Trigger Link, an output trigger pulse is available on the programmed TRIGGER LINK output line. For all other event sources, the output trigger pulse is available at the METER COMPLETE connector. The Output Trigger in this layer is disabled when Source Bypass is disabled (Scan Trigger Control set to Acceptor).

After all other operations in the next layer are complete, the instrument can be returned to the scan layer by programming the instrument for additional scans. The Scan Count option is used to set the scan count to a finite value (where n = 1 to 99999) or for an infinite number of scans. Selecting BENCH RESET from the SAVESETUP option of the main menu sets the scan count to infinite; selecting GPIB RESET sets the scan count to one.

After the instrument leaves the scan layer, operation proceeds into the measure layer (trigger layer).

Measure layer

NOTE

For bus operation, this layer is called Trigger.

In general, measure events control the measurement (or scan) rate. With a measure source of Immediate, operation immediately proceeds to the Delay. Selecting BENCH or GPIB RESET from the SAVESETUP option of the main menu also sets the measure source to Immediate. With one of the other sources selected, the instrument waits until the appropriate event occurs:

- With the External source selected, the instrument waits for an input trigger via EXTERNAL TRIGGER on the rear panel.
- With the Manual source selected, the instrument waits until the front panel TRIG key is pressed.
- With the GPIB source selected, the instrument waits for a bus trigger (GET or *TRG).
- With the Trigger Link source selected, the instrument waits for an input trigger via TRIGGER LINK on the rear panel.
- With the Timer source selected, the first measurement occurs immediately. Each additional measurement occurs at a rate determined by the programmed timer interval (1msec to 999999.999sec).
- With the HOLD source selected, the instrument does not respond to any of the event sources. Another source must be selected to acquire a reading.

After the programmed measure event is detected, the instrument waits for the programmed Delay to time out. The measure layer Delay can be set from 0 to 999999.999sec. Selecting BENCH or GPIB RESET from the SAVESETUP option of the main menu sets the Delay to zero seconds.

As can be seen in the flowchart, there is a path that allows operation to loop around the source. When Source Bypass is enabled (Measure Trigger Control set to Source) and the event source is External or Trigger Link, operation loops around the source on the initial pass through the measure layer. If programmed for another measurement (measure count > 1), the bypass loop is not in effect even though it is still enabled. The Source Bypass loop resets (is in effect) if operation goes back into the scan layer.

At this point, a measurement is performed (Device Action). Note that a Device Action could include, among others, a function change, range change, or a channel scan (if scanner

is enabled). A channel is scanned (closed) before a measurement is taken. When scanning channels, the previous channel opens and the next channel closes (break-before-make). In this case, the settling time delay for the relay is included in the Device Action.

After a Device Action is performed, an Output Trigger occurs. If the measure source is programmed for Immediate, External, Manual, GPIB, or Timer, the output trigger pulse is available at the METER COMPLETE connector. If the Trigger Link source is selected, Output Trigger action occurs as follows:

- If the asynchronous Trigger Link mode is selected, the output trigger pulse is available on the programmed TRIGGER LINK output line.
- If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (Measure Trigger Control set to Acceptor), the Trigger Link line is released (goes high).
- If the semi-synchronous Trigger Link mode is selected and the Source Bypass is enabled (Measure Trigger Control set to Source), the Trigger Link line is pulled low and then released.

NOTE

See paragraph 3.7.7 for details on using the Trigger Link.

After the Device Action and an output trigger occurs, the instrument returns (if programmed to do so) to the beginning of the measure layer to perform another measurement. The Measure Count option is used to set the measure count to a finite value (where n = 1 to 99999) or for an infinite number of measurements. Selecting BENCH RESET from the SAVESETUP option of the main menu sets the measure count to infinite; selecting GPIB RESET sets the measure count to one.

3.7.2 Configuring the measure layer

The measure layer is used for the following operations:

- To select the measuring event (SOURCE) for the instrument.
- To delay operation in the measure layer.
- To designate the number of measurements the instrument will make (COUNT).
- To enable or disable the Source Bypass.

Perform the following steps to display the measure layer menu:

1. Display the CONFIGURE TRIGGER menu by pressing the CONFIG key and then the TRIG key.
2. Use the cursor keys (◄ and ►) to place the cursor on MEASURE and press ENTER to access the following menu:

SETUP MEASURE LAYER
SOURCE DELAY COUNT CONTROL

SOURCE

This menu item selects the event that controls the measure source. To select it, place the cursor on SOURCE and press ENTER. The following menu is displayed:

SELECT MEASURE SRC
IMMEDIATE EXTERNAL MANUAL ►
◄ GPIB TRIGLINK TIMER HOLD

IMMEDIATE: With this selection, events (such as TIMER and EXTERNAL triggers) do not control the measurement interval. Once the Model 2001 starts measuring, it will take readings as fast as its measurement configuration allows.

Select immediate triggering from the SELECT MEASURE SRC menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument returns to the SETUP measure layer menu.

EXTERNAL: With this selection, external triggers are used to control the measure source. Each trigger stimulus applied to the Model 2001 performs a device action, as defined by the trigger model. In addition to a measurement, this may include range changing, filtering, calculations, data storing, scanning, and other operations.

The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 3.7.6 for detailed information on external triggering.

NOTE

Front panel TRIG key (see MANUAL) is active with external triggering selected. Pressing the TRIG key performs a device action.

To select external triggering from the SELECT MEASURE SRC menu, place the cursor on EXTERNAL and press ENTER. The instrument returns to the SETUP measure layer menu.

MANUAL: With this selection, the front panel TRIG key controls the measure source. A device action is performed when the TRIG key is pressed.

NOTE

Front panel TRIG key is active when EXTERNAL, GPIB, TRIGLINK, or TIMER is selected.

To select manual triggering (TRIG key) from the SELECT MEASURE SRC menu, place the cursor on MANUAL and press ENTER. The instrument returns to the SETUP measure layer menu.

GPIB: With this selection, bus triggers control the measure source. When the Model 2001 receives a bus trigger (GET or *TRG), it performs a device action, as defined by the trigger model. In addition to a measurement, this may include range changing, filtering, calculations, data storing, scanning, and other operations. See Section 4 for detailed information on bus triggers.

NOTE

Front panel TRIG key (see MANUAL) is active with bus triggering selected. Pressing the TRIG key performs a device action.

To select bus triggering from the SELECT MEASURE SRC menu, place the cursor on GPIB and press ENTER. The display returns to the SETUP measure layer menu.

TRIGLINK: With this selection, the measure source is controlled by the Trigger Link of the Model 2001. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments.

When the Model 2001 receives a trigger over the Trigger Link, it performs a device action, as defined by the trigger model. In addition to a measurement, this may include range changing, filtering, calculations, data storing, scanning, and other operations.

See paragraph 3.7.7 for details on using the Trigger Link.

NOTE

Front panel TRIG key (see MANUAL) is active with the Trigger Link selected. Pressing the TRIG key performs a device action.

To select the Trigger Link from the SELECT MEASURE SRC menu, place the cursor on TRIGLINK and press ENTER. The following menu is displayed:

SET TRIGGERLINK MODE
ASYNCHRONOUS SEMI-SYNCHRONOUS

Asynchronous: The asynchronous trigger link mode is used for trigger configurations that require input and output triggers to be routed on separate lines. Perform the following steps to select the asynchronous mode, and to select the input and output trigger lines for the Model 2001:

1. With the SET TRIGGERLINK MODE menu displayed, place the cursor on ASYNCHRONOUS and press ENTER. The following message is displayed:

   SELECT INPUT LINE
   #1 #2 #3 #4 #5 #6

   The position of the cursor indicates the presently selected input line.

2. To select a trigger input line for the Model 2001, place the cursor on the desired line number and press ENTER. The following message is displayed:

   SELECT OUTPUT LINE
   #1 #2 #3 #4 #5 #6

   The position of the cursor indicates the presently selected output line.

3. To select a trigger output line for the Model 2001, place the cursor on a different line number and press ENTER. The instrument returns to the SELECT MEASURE SOURCE menu. Note that you cannot use the same trigger line for both input and output.

Semi-Synchronous: In this mode, the input and output triggers for the Model 2001 are assigned to the same line. Perform the following steps to select the semi-synchronous mode, and to select the trigger line:

1. With the SET TRIGGERLINK MODE menu displayed, place the cursor on SEMI-SYNCHRONOUS and press ENTER. The following message is displayed:

   SET SEMI-SYNC LINE
   #1 #2 #3 #4 #5 #6

   The position of the cursor indicates the presently selected trigger line.

2. To select a trigger line for the Model 2001, place the cursor on the desired line number and press ENTER. The instrument returns to the SELECT MEASURE SRC menu.

TIMER: Use the timer to control the time interval between measurements.

The timer can be set for an interval from 0.001 seconds (1msec) to 999999.999 seconds with 1msec resolution.

After a measurement is triggered to start, the next measurement starts at the end of the programmed timer interval. If however, the programmed timer interval is shorter than the time it takes to complete a single measurement, the next measurement does not start until the previous one is done.

NOTE

Front panel TRIG key (see MANUAL) is active with the timer selected. Pressing the TRIG key after the completion of a measurement starts the next measurement (assuming the Model 2001 is programmed for another measurement; see COUNT).

Perform the following steps to use the timer:

1. With the SELECT MEASURE SRC menu displayed, place the cursor on TIMER and press ENTER. A message indicating the presently set time interval (in seconds) is displayed:

   INTRVL = 000001.000

2. To retain the displayed timer interval, press EXIT or ENTER. The instrument returns to the SELECT MEASURE SRC menu.
3. To set a different time interval, use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits. Press ENTER when done to return to the SELECT MEASURE SRC menu.

HOLD: When HOLD is selected, the measure source is suppressed. As a result, measuring is stopped and does not continue until HOLD is cancelled by selecting one of the other measure source selections. Select HOLD from the SELECT MEASURE SRC menu by placing the cursor on HOLD and pressing ENTER. The instrument returns to the SETUP measure layer menu.

DELAY

This delay is used to hold up operation in the measure layer. After the measure event occurs, the instrument waits until the delay period times out (0 - 999999.999sec) before performing a device action.

COUNT

With this selection, you determine the number (count) of measurements per scan sequence. The user programmed count can be smaller, equal to, or larger than the number of channels in the scan list. For example, if the scan list is made up of four channels, you can program a count of 12. With this count value, the instrument repeats the scan three times. An advantage of repeating channels (rather than scans) is that delays in the scan layer of operation are avoided. The measure delays among all 12 channels are the same.

With the SETUP measure layer menu displayed, select this menu item by placing the cursor on COUNT and pressing ENTER. The following menu is displayed:

MEASURE COUNT
INFINITE ENTER-CHAN-COUNT

INFINITE: Use this selection to continuously repeat measurements (and looping in the measure layer). With the MEASURE COUNT menu displayed, select this menu item by placing the cursor on INFINITE and pressing ENTER. The display returns to the SETUP measure layer menu.

ENTER-CHAN-COUNT: With this selection, the user determines the number of readings per scan. You can program the Model 2001 to measure up to 99999 times. Perform the following steps to enter the measure count:

1. With the MEASURE COUNT menu displayed, place the cursor on ENTER-CHAN-COUNT and press ENTER. A message indicating the present scan count is displayed:

   MEASURE COUNT = 00001

2. The above measure count indicates that the instrument will measure one time.
3. To program for a different count (1 to 99999), use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits.
4. With desired count value displayed, press ENTER. The display returns to the SETUP measure layer menu.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the measure event on the first pass through the measure layer. With the SETUP measure layer menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu is displayed:

TRIGGER CONTROL
SOURCE ACCEPTOR

SOURCE: With this selection, the source bypass is enabled. The measure event will be bypassed on the first pass through the scan layer. This allows operation to proceed to the Delay and Device Action without having to wait for the programmed event.

ACCEPTOR: With this selection, the source bypass is disabled.

3.7.3 Configuring the scan layer

The scan layer is used for the following operations:

- To select the scanning event (SOURCE) for the instrument.
- To delay operation in the scan layer.
- To designate the number of scan sequences the instrument will perform (COUNT).
- To enable or disable the Source Bypass.

Perform the following steps to display the SCAN LAYER menu:

1. Display the CONFIGURE TRIGGER menu by pressing the CONFIG key and then the TRIG key.
2. Use the cursor keys (◄ and ►) to place the cursor on SCAN and press ENTER to access the following menu:

SETUP SCAN LAYER
SOURCE DELAY COUNT CONTROL

SOURCE

This menu item selects the event that controls the scan source. To select it, place the cursor on SOURCE and press ENTER. The following menu is displayed:

SELECT SCAN SOURCE
IMMEDIATE EXTERNAL MANUAL ►
◄ GPIB TRIGLINK TIMER HOLD

IMMEDIATE: With this selection, operation passes immediately into the measure layer.

Select immediate triggering from the SELECT SCAN SOURCE menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument returns to the SETUP SCAN LAYER menu.

EXTERNAL: With this selection, external triggers are used to control the scan source. A trigger stimulus applied to the Model 2001 passes operation into the measure layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 3.7.6 for detailed information on external triggering.

NOTE

Front panel TRIG key (see MANUAL) is active with external triggering selected. Pressing the TRIG key passes operation into the measure layer.

To select external triggering from the SELECT SCAN SOURCE menu, place the cursor on EXTERNAL and press ENTER. The instrument returns to the SETUP SCAN LAYER menu.

MANUAL: With this selection, the front panel TRIG key controls the scan source. Operation passes into the measure layer when the TRIG key is pressed.

NOTE

The front panel TRIG key is active when EXTERNAL, GPIB, TRIGLINK, or TIMER is selected.

To select manual triggering (TRIG key) from the SELECT SCAN SOURCE menu, place the cursor on MANUAL and press ENTER. The instrument returns to the SETUP SCAN LAYER menu.

GPIB: With this selection, bus triggers control the scan source. Operation passes immediately into the measure layer when a bus trigger (GET or *TRG) is received by the Model 2001. See Section 4 for detailed information on bus triggers.

NOTE

Front panel TRIG key (see MANUAL) is active with bus triggering selected. Pressing the TRIG key passes operation into the measure layer.

To select bus triggering from the SELECT SCAN SOURCE menu, place the cursor on GPIB and press ENTER. The display returns to the SETUP SCAN LAYER menu.

TRIGLINK: With this selection, the scan source is controlled by the Trigger Link of the Model 2001. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the measure layer when the Model 2001 receives a trigger over the Trigger Link. See paragraph 3.7.7 for details on using the Trigger Link.

NOTE

Front panel TRIG key (see MANUAL) is active with the Trigger Link selected. Pressing the TRIG key passes operation into the measure layer.

To select the Trigger Link from the SELECT SCAN SOURCE menu, place the cursor on TRIGLINK and press ENTER. The following menu is displayed:

SELECT INPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the presently selected input line.

To select a trigger input line for the Model 2001, place the cursor on the desired line number and press ENTER. The following message is displayed:

SELECT OUTPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the presently selected output line.

To select a trigger output line for the Model 2001, place the cursor on a different line number and press ENTER. The instrument returns to the SELECT SCAN SOURCE menu. Note that you cannot use the same trigger line for both input and output.

TIMER: Use the timer feature to control the time interval between scan sequences when scanning. The timer can be set for an interval from 0.001 seconds (1msec) to 999999.999 seconds with 1msec resolution.

After a scan sequence is triggered to start, the next scan sequence starts at the end of the programmed timer interval. If however, the programmed timer interval is shorter than the time it takes to complete a single scan sequence, the next scan sequence does not start until the previous one is done.

NOTE

Front panel TRIG key (see MANUAL) is active with the timer selected. Pressing the TRIG key after the completion of a scan sequence starts the next scan sequence (assuming the Model 2001 is programmed for another scan sequence; see COUNT).

Perform the following steps to use the timer:

With the SELECT SCAN SOURCE menu displayed, place the cursor on TIMER and press ENTER. A message indicating the presently set time interval (in seconds) is displayed:

INTRVL = 000001.000

1. To retain the displayed timer interval, press EXIT or ENTER. The instrument returns to the SELECT SCAN SOURCE menu.
2. To set a different time interval, use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits. Press ENTER when done to return to the SELECT SCAN SOURCE menu.

HOLD: When HOLD is selected, the scan source is suppressed. As a result, operation does not pass into the measure layer until HOLD is cancelled by selecting one of the other scan source selections. Select HOLD from the SELECT SCAN SOURCE menu by placing the cursor on HOLD and pressing ENTER. The instrument returns to the SETUP SCAN LAYER menu.

DELAY

This delay is used to hold up operation in the scan layer. After the scan event occurs, the instrument waits until the delay period times out (0 to 999999.999sec) before proceeding to the measure layer.

COUNT

This menu item defines the number of times operation returns to the scan layer. With the SETUP SCAN LAYER menu displayed, select this menu item by placing the cursor on COUNT and pressing ENTER. The following menu is displayed:

NUMBER OF SCANS
INFINITE ENTER-SCAN-COUNT

INFINITE: Use this selection to continuously return operation to the scan layer. Select continuous scanning from the SCAN COUNT menu by placing the cursor on INFINITE and pressing ENTER. The display returns to the SETUP SCAN LAYER menu.

ENTER-SCAN-COUNT: With this selection, the user determines the number of times operation returns to the scan layer. You can program the Model 2001 to scan up to 99999 times. Perform the following steps to enter the scan count:

1. With the SCAN COUNT menu displayed, place the cursor on ENTER-SCAN-COUNT and press ENTER. A message indicating the present scan count is displayed:

SCAN COUNT = 00001

The above scan count indicates that the instrument will scan one time.

2. To program for a different count (1 to 99999), use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits.
3. With desired count value displayed, press ENTER. The display returns to the SETUP SCAN LAYER menu.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the scan event on the first pass through the scan layer. With the SETUP SCAN LAYER menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu is displayed:

TRIGGER CONTROL
SOURCE ACCEPTOR

SOURCE: With this selection, the source bypass is enabled. The scan event will be bypassed on the first pass through the scan layer. This allows operation to proceed into the measure layer without having to wait for the programmed event.

ACCEPTOR: With this selection, the source bypass is disabled.

3.7.4 Configuring the arm layer

The arm layer is used for the following operations:

- To select the arming event (SOURCE) for the instrument.
- To designate the number of times the instrument is to be armed (COUNT).
- To enable or disable the Source Bypass.

Perform the following steps to display the arm layer menu:

1. Display the CONFIGURE TRIGGER menu by pressing the CONFIG key and then the TRIG key.
2. Use the cursor keys (◄ and►) to place the cursor on ARM and press ENTER to access the following menu:

   SETUP ARM LAYER
   SOURCE COUNT CONTROL

SOURCE

This menu item selects the event that controls the arm source. To select it, place the cursor on SOURCE and press ENTER. The following menu is displayed:

SELECT ARM SOURCE
IMMEDIATE EXTERNAL MANUAL ►
◄ GPIB TRIGLINK HOLD

IMMEDIATE: With this selection, operation passes immediately into the scan layer.

Select immediate triggering from the SELECT ARM SOURCE menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument returns to the SETUP arm layer menu.

EXTERNAL: With this selection, external triggers are used to control the arm source. A trigger stimulus applied to the Model 2001 passes operation into the scan layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 3.7.6 for detailed information on external triggering.

NOTE

Front panel TRIG key (see MANUAL) is active with external triggering selected. Pressing the TRIG key passes operation into the scan layer.

To select external triggering from the SELECT ARM SOURCE menu, place the cursor on EXTERNAL and press ENTER. The instrument returns to the SETUP arm layer menu.

MANUAL: With this selection, the front panel TRIG key controls the arm source. Operation passes into the scan layer when the TRIG key is pressed.

NOTE

The front panel TRIG key is active when EXTERNAL, GPIB, or TRIGLINK is selected.

To select manual triggering (TRIG key) from the SELECT ARM SOURCE menu, place the cursor on MANUAL and press ENTER. The instrument returns to the SETUP arm layer menu.

GPIB: With this selection, bus triggers control the arm source. Operation passes immediately into the scan layer

when a bus trigger (GET or *TRG) is received by the Model 2001. See Section 4 for detailed information on bus triggers.

NOTE

Front panel TRIG key (see MANUAL) is active with bus triggering selected. Pressing the TRIG key passes operation into the scan layer.

To select bus triggering from the SELECT ARM SOURCE menu, place the cursor on GPIB and press ENTER. The display returns to the SETUP arm layer menu.

TRIGLINK: With this selection, the arm source is controlled by the Trigger Link of the Model 2001. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the scan layer when the Model 2001 receives a trigger over the Trigger Link. See paragraph 3.7.7 for details on using the Trigger Link.

NOTE

Front panel TRIG key (see MANUAL) is active with the Trigger Link selected. Pressing the TRIG key passes operation into the scan layer.

To select the Trigger Link from the SELECT ARM SOURCE menu, place the cursor on TRIGLINK and press ENTER. The following menu is displayed:

SELECT INPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the presently selected input line.

To select a trigger input line for the Model 2001, place the cursor on the desired line number and press ENTER. The following message is displayed:

SELECT OUTPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the presently selected output line.

To select a trigger output line for the Model 2001, place the cursor on a different line number and press ENTER. The instrument returns to the SELECT ARM SOURCE menu. Note that you cannot use the same trigger line for both input and output.

HOLD: When HOLD is selected, the arm source is suppressed. As a result, operation does not pass into the scan layer until HOLD is cancelled by selecting one of the other arm source selections. Select HOLD from the SELECT ARM SOURCE menu by placing the cursor on HOLD and pressing ENTER. The instrument returns to the SETUP arm layer menu.

COUNT

This menu item defines the number of times operation returns to the arm layer. With the SETUP arm layer menu displayed, select this menu item by placing the cursor on COUNT and pressing ENTER. The following menu is displayed:

ARM COUNT
INFINITE ENTER-ARM-COUNT

INFINITE: Use this selection to continuously return operation to the arm layer. Select continuous arming from the ARM COUNT menu by placing the cursor on INFINITE and pressing ENTER. The display returns to the SETUP arm layer menu.

ENTER-ARM-COUNT: With this selection, the user determines the number of times operation returns to the arm layer. You can program the Model 2001 to arm up to 99999 times. Perform the following steps to enter the arm count:

1. With the ARM COUNT menu displayed, place the cursor on ENTER-ARM-COUNT and press ENTER. A message indicating the present arm count is displayed:

   ARM COUNT = 00001

   The above arm count indicates that the instrument will arm one time.
2. To program for a different count (1 to 99999), use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits.
3. With desired count value displayed, press ENTER. The display returns to the SETUP arm layer menu.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the arm event on the first pass through the arm layer. With the SETUP arm layer menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu is displayed:

TRIGGER CONTROL
SOURCE ACCEPTOR

SOURCE: With this selection, the source bypass is enabled. The arm event will be bypassed on the first pass through the arm layer. This allows operation to proceed into the scan layer without having to wait for the programmed event.

ACCEPTOR: With this selection, the source bypass is disabled.

3.7.5 Halting triggers

The Halt option of the CONFIGURE TRIGGER menu is used to disarm the instrument and place it in the idle state. You can press the TRIG key to resume front panel triggers.

Perform the following steps to halt triggers:

1. Display the CONFIGURE TRIGGER menu by pressing the CONFIG key and then the TRIG key.
2. Use the cursor keys (◄ and ►) to place the cursor on HALT and press ENTER to display the following temporary message:

   TRIGGERS HALTED
   Press TRIG key to resume.

3.7.6 External triggering

The Model 2001 has BNC connections on the rear panel for external triggering (see Figure 3-23). The EXTERNAL TRIGGER INPUT jack allows the Model 2001 to be triggered by other instruments. The METER COMPLETE OUTPUT jack allows the Model 2001 to trigger other instruments.

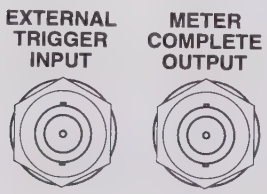


Figure 3-23
External triggering connectors (BNC)

External trigger

The EXTERNAL TRIGGER INPUT jack requires a falling-edge, TTL-compatible pulse with the specifications shown in Figure 3-24.

In general, external triggers can be used as events to control measure operations. For the Model 2001 to respond to external triggers, the appropriate layers of trigger model must be configured for it. Paragraphs 3.7.2 through 3.7.4 explain how to program the three layers of the measurement.

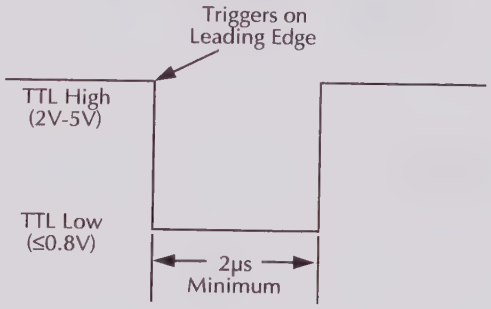


Figure 3-24
External triggering and asynchronous trigger link input pulse specifications

Meter complete

The METER COMPLETE OUTPUT jack provides a TTL-compatible output pulse that can be used to trigger other instruments. The specifications for this trigger pulse are shown in Figure 3-25.

Typically, you would want the Model 2001 to output a trigger after the settling time of each measurement. (Settling time includes the internally set measurement settling time and the user programmed DELAY period.) An output completion pulse occurs after each measurement as long as the measure source is set to external, timer, manual, or immediate. See paragraph 3.7.2 for details on programming the measure layer.

The Model 2001 can also output a completion pulse while in the scan and/or arm layers of operation. Figure 3-22 shows where these triggers occur in the trigger model. If the scan layer Source Bypass is enabled (Control = Source) and the Scan Source is programmed for External, an output trigger occurs on each return path through the scan layer. If the arm layer Source Bypass is enabled (Control = Source) and the Arm Source is programmed for External, an output trigger occurs on each return path through the arm layer. See paragraphs 3.7.3 and 3.7.4 for programming the Scan and arm layers.

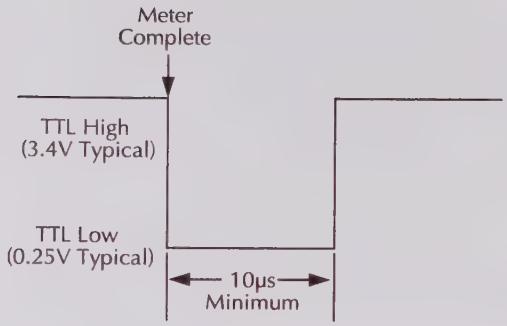


Figure 3-25
Meter complete and asynchronous trigger link output pulse specifications

External triggering example #1

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a multimeter. Such a test system is shown in Figure 3-26, which uses a Model 2001 Multimeter to measure ten DUTs switched by a Model 7011 multiplexer card in a Model 7001 Switch System.

The external trigger connections for this test are shown in Figure 3-27. Channel Ready (output) of the Model 7001 is connected to External Trigger Input of the Model 2001. Meter Complete Output of the Model 2001 is connected to External Trigger (input) of the Model 7001.

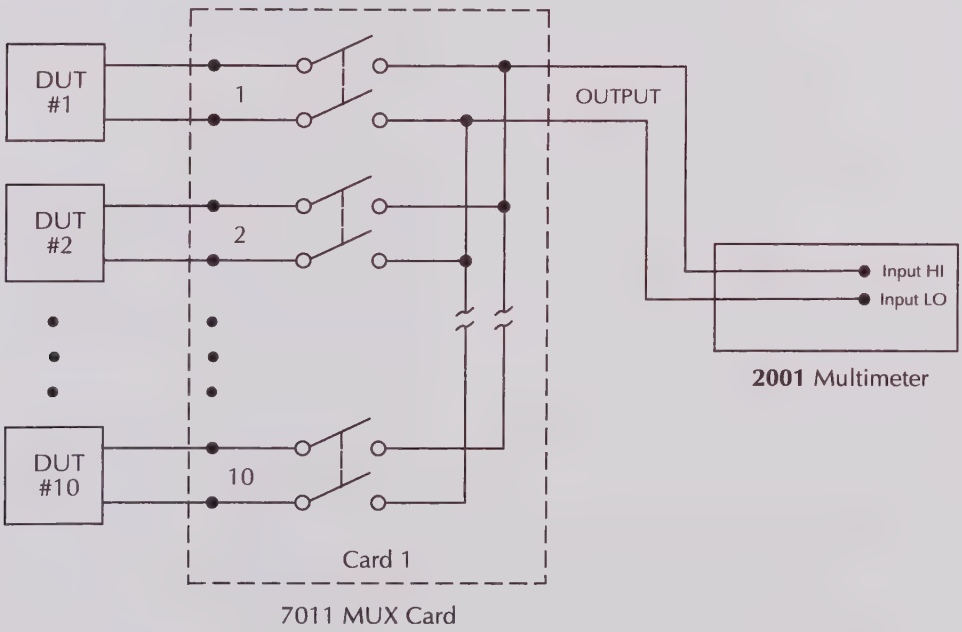


Figure 3-26
DUT test system

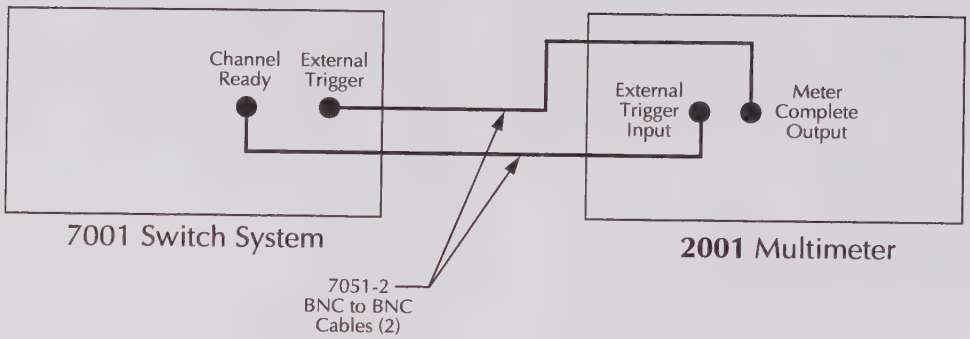


Figure 3-27
External trigger connectors

For this example, the Models 2001 and 7001 are configured as follows:

Model 2001:

Idle State:
Bench reset = :INIT:CONT ON*

Arm layer:
Arm source = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:
Scan source = Immediate*
Scan count = Infinite*
Scan trigger control = Acceptor*

Measure layer:
Measure source = External
Measure count = Infinite*
Measure trigger control = Acceptor*

* Indicates that the setting is the BENCH RESET (and factory) default condition.

Model 7001:

Idle State:
Reset = :INIT:CONT OFF*

Scan List = 1!1-1!10,

Arm layer:
Arm spacing = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:
Scan spacing = Immediate*
Number of scans = 1
Scan trigger control = Acceptor*

Channel Layer:
Channel spacing = External
Number of channels = Use Scanlist length*
Channel trigger control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that the Model 2001 is reset to BENCH defaults. With this selection, the multimeter stays armed. Since the arm source and scan source are set to Immediate, the Model 2001 waits in the measure layer for a trigger.

With the Channel Trigger Control of the Model 7001 set for Source, scan operation initially bypasses the need for an external trigger to close the first channel. Since arm spacing and scan spacing are set to Immediate, the scan starts as soon as the scanner is taken out of the idle state by pressing the STEP key. When the front panel STEP key is pressed:

- The scanner arms and closes the first channel.
- After Channel 1!1 settles, a trigger is sent from Channel Ready of the Model 7001 to External Trigger Input of the Model 2001 to trigger a measurement of DUT #1.
- After the Model 2001 completes the measurement, it outputs a trigger from Meter Complete Output to External Trigger of the Model 7001, which closes the next channel.
- After Channel 1!2 settles, a trigger is sent to the Model 2001 to trigger a measurement of DUT #2.

This process continues until all ten channels are scanned and measured.

The data store capability of the Model 2001 could be used to store the measurements as they occur. Just press the STORE key to set the number of readings to store, then press ENTER. The Model 2001 waits (with the asterisk annunciator lit) for an external trigger from the Model 7001 before taking a reading, storing it, and sending a trigger pulse.

External triggering example #2

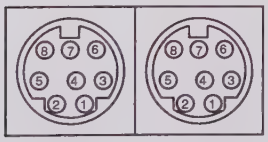
External triggering can also be used in a test system consisting of a Model 2001 Multimeter and a Model 706 Scanner with an appropriate scanner card.

The external trigger connections are the same as those shown in Figure 3-27 for the Models 2001 and 7001. Channel Ready Output of the Model 706 is connected to External Trigger Input of the Model 2001. External Trigger Input of the Model 706 is connected to Meter Complete Output of the Model 2001.

The trigger configuration of the Model 2001 does not change from the previous example. The Model 706 is configured for external triggering.

3.7.7 Trigger Link

The Model 2001 has enhanced external triggering capabilities using the Trigger Link. The Trigger Link has six lines allowing up to six instruments to be controlled over this trigger bus. The 8-pin micro-DIN sockets used for the Trigger Link are shown in Figure 3-28.



Pin	Trigger Link Line
1	Line #1
2	Line #2
3	Line #3
4	Line #4
5	Line #5
6	Line #6
7	Digital Common
8	Digital Common

Figure 3-28
Trigger link connectors

NOTE

The two rear panel Trigger Link connectors are actually connected in parallel. It does not matter which connector you use when connecting the Trigger Link to another instrument.

In general, Trigger Link input triggers to the Model 2001 are used to control the measure operation. For the Model 2001 to respond to Trigger Link compatible triggers, the appropriate layers of the trigger model must be programmed for it. For example, if you want Trigger Link input triggers to control the measuring process, you must program Measure Source for TRIGLINK trigger events. Typically, a Trigger Link output trigger from the Model 2001 would be used to trigger a scanner to close the next channel.

There are two modes of operation for Trigger Link: asynchronous and semi-synchronous. In the asynchronous mode, separate lines are used for input and output triggers; in the semi-synchronous mode, the same line is used for both input and output triggers.

Asynchronous operation

In the asynchronous operating mode, Trigger Link functions fundamentally in the same manner as External Triggering (see paragraph 3.7.6). Like External Triggering, the asynchronous mode uses separate lines for input and output triggers. Also, the asynchronous mode uses the same TTL-compatible pulses as External Triggering. The specifications for the input and output trigger signals of asynchronous mode are shown in Figure 3-24 and Figure 3-25, respectively.

For typical asynchronous Trigger Link operation, the measure layer is configured with Measure Source set to TRIGLINK and Triggerlink mode set to ASYNCHRONOUS. You must also select input and output lines for the measure layer. Input and output triggers can be set to any of the six lines, but they cannot use the same line. For example, if you select line #1 for input triggers, then output triggers must use one of the other five lines (#2 through #6).

During operation in the measure layer, each Trigger Link input trigger makes a measurement. After the user-programmed DELAY and the measurement settling time, the Model 2001 outputs a Trigger Link completion pulse (typically to a scanner to close the next channel). The measure layer is configured using the CONFIG-TRIG menu (see paragraph 3.7.2).

The scan layer and/or arm layer can also be programmed for Trigger Link, where Scan Source is set to TRIGLINK, and Arm Source is set to TRIGLINK. When using Trigger Link in these layers, you must also select input and output lines as you did in the measure layer. Keep in mind that you can use the same lines in the Scan and arm layers as selected in the measure layer.

Asynchronous Trigger Link example #1

In a typical test system, you may want to close a channel and then measure the DUT connected to the channel with a multimeter. Such a test system is shown in Figure 3-29, which uses a Model 2001 Multimeter to measure ten DUTs switched by a Model 7011 multiplexer card in a Model 7001 Switch System.

The Trigger Link connections for this test system are shown in Figure 3-30. Trigger Link of the Model 2001 is connected to Trigger Link of the Model 7001 Switch System. Notice that only one Trigger Link cable is needed.

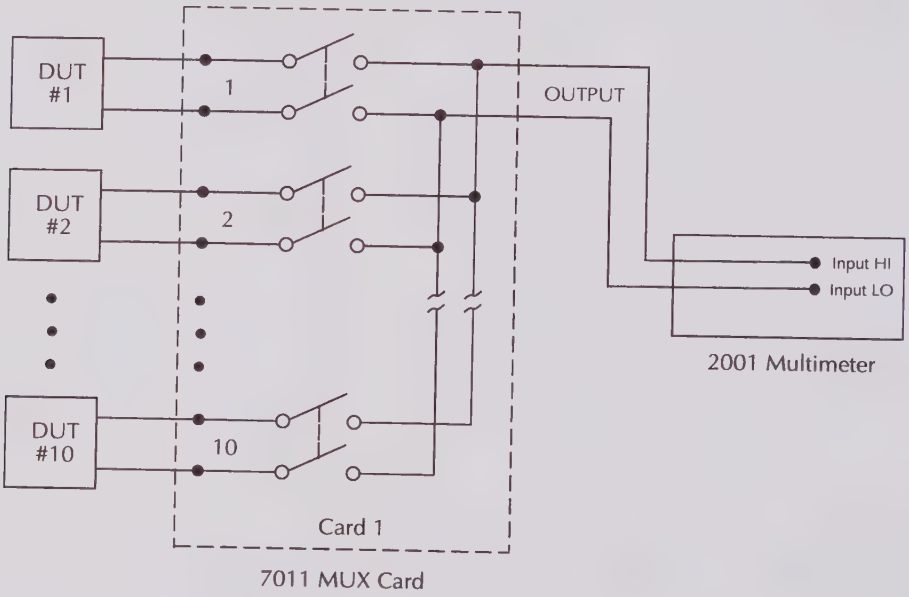


Figure 3-29
DUT test system

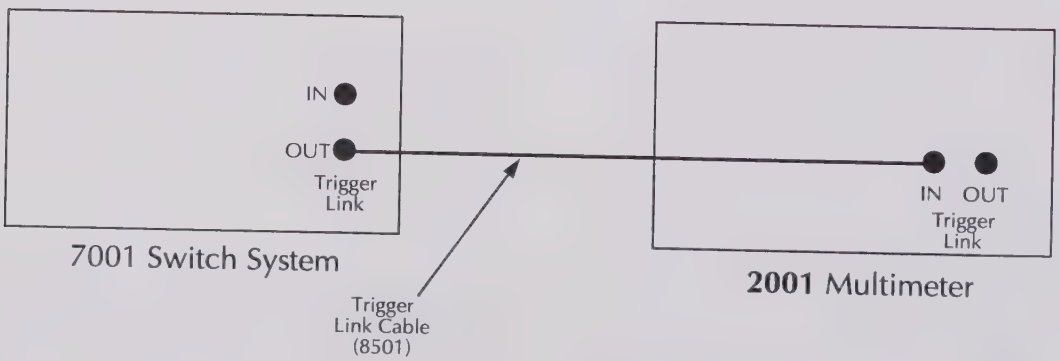


Figure 3-30
Trigger Link connections (asynchronous example #1)

For this example, the Models 2001 and 7001 are configured as follows:

Model 2001:

Idle state:
Bench reset = :INIT:CONT ON*

Arm layer:
Arm source = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:
Scan source = Immediate*
Scan count = Infinite*
Scan trigger control = Acceptor*

Measure layer:
Measure source = TrigLink
Trigger link mode = Asynchronous*
Input line = #2*
Output line = #1*
Measure count = 10
Measure trigger control = Acceptor*

* Indicates that the setting is the BENCH RESET (and factory) default condition.

Model 7001:

Idle state:
Reset = :INIT:CONT OFF*

Scan list = 1!1-1!10,

Arm layer:
Arm spacing = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:
Scan spacing = Immediate*
Number of scans = 1
Scan trigger control = Acceptor*

Channel Layer:
Channel spacing = TrigLink
Trigger link mode = Asynchronous*
Input line = #1*
Output line = #2*
Number of channels = Use Scanlist length*
Channel trigger control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that the Model 2001 is reset to BENCH defaults. With this selection, the multimeter stays armed. Since the arm source and scan source are set to Immediate, the Model 2001 waits in the measure layer for a trigger.

With the Channel Trigger Control of the Model 7001 set for Source, scan operation initially bypasses the need for a Trigger Link trigger to close the first channel. Since arm spacing and scan spacing are set to Immediate, the scan starts as soon as the scanner is taken out of the idle state by pressing the STEP key.

To run the test and store the readings in the Model 2001, press STORE on the multimeter, enter the desired number of readings (ten), and press ENTER. The Model 2001 waits (with the asterisk annunciator lit) for a Trigger Link trigger from the Model 7001.

Press STEP on the Model 7001 to start the scan. The scanner's output pulse triggers the Model 2001 to take a reading, store it, and send a trigger pulse. The following explanation on operation is referenced to the operation model shown in Figure 3-31.

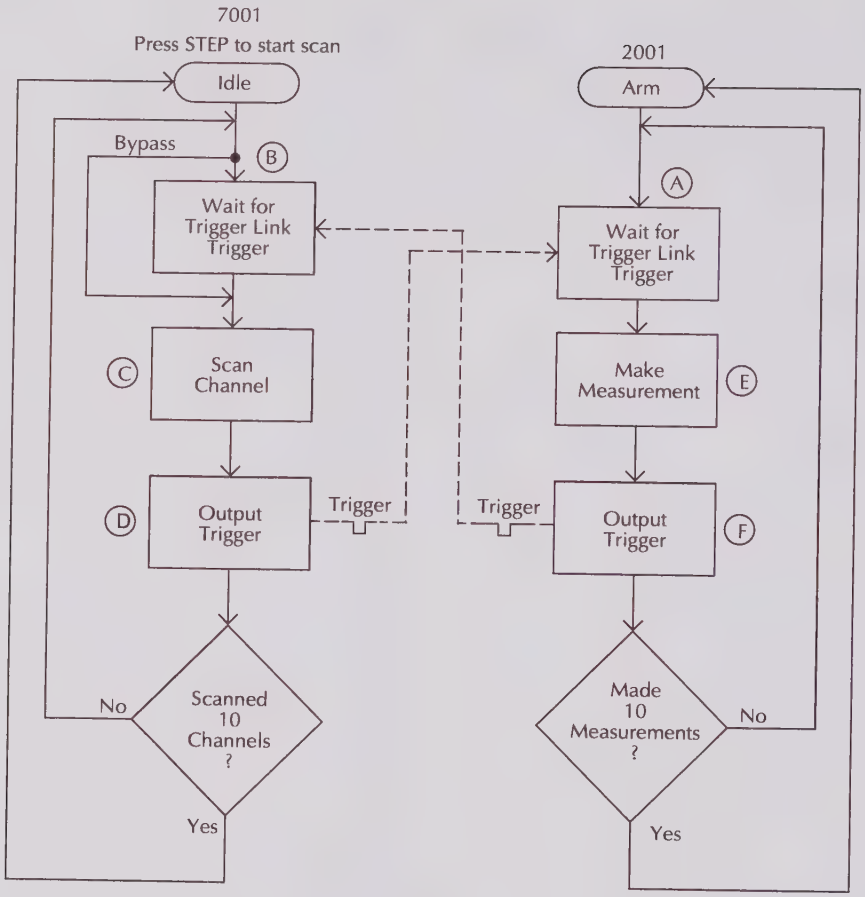


Figure 3-31
Operation model for asynchronous trigger link example #1

A The BENCH RESET condition arms the Model 2001 and places multimeter operation at point A in the flowchart, where it is waiting for a Trigger Link trigger. Note that since both the arm layer and scan layer are programmed for Immediate Source, operation immediately drops down to the measure layer at point A.

B Pressing STEP takes the Model 7001 out of the idle state and places operation at point B in the flowchart. Since both the arm layer and scan layer are programmed for Immediate Spacing, operation drops down to the channel layer at point B.

C Since Channel Trigger Source is set to Source, the scan does not wait at point B for a trigger. Instead, it bypasses "Wait for Trigger Link Trigger" and closes the first channel (point C). Note that the Bypass is in effect only on the first pass through the model into a layer.

D After the relay settles, the Model 7001 outputs a Channel Ready pulse (point D). Since the instrument is programmed to scan ten channels, operation loops back up to point B, where it waits for an input trigger. Note that Bypass is no longer in effect.

E and **F** Remember that the Model 2001 operation is at point A waiting for a trigger. The output Channel Ready pulse from the Model 7001 triggers the multimeter to measure DUT #1 (point E). After the measurement is complete, the Model 2001 outputs a completion pulse (point F) and then loops back to point A, where it waits for another input trigger.

The trigger applied to the Model 7001 from the Model 2001 closes the next channel in the scan. This triggers the multimeter to measure the next DUT. The process continues until all ten channels are scanned and measured.

External Triggering and Trigger Link

As previously mentioned, the trigger pulses for the asynchronous Trigger Link are identical to the trigger pulses used for External Triggering. The only thing that prevents them from being used together in a test system is connection incompatibility. Trigger Link uses 8-pin micro-DIN connectors while External Triggering uses BNC connectors.

This connection problem can be solved by using the Model 8502 Trigger Link Adapter. The adapter has two 8-pin micro-DIN connectors and six BNC connectors. The micro-DIN connectors mate directly to the Trigger Link connector on the Model 2001 using a trigger link cable. The BNC connectors mate directly to the External Triggering BNC connectors on other instruments using standard male BNC to BNC cables.

Figure 3-32 shows how a Keithley Model 706 Scanner can be connected to the Trigger Link of the Model 2001 using the adapter. With this adapter, a Model 706 could be substituted for the Model 7001 in the previous example (Asynchronous Trigger Link example #1). With the Model 706 set for External Triggering, the test would start when the single scan mode is selected and initiated.

Asynchronous Trigger Link example #2

In this example, the test system (Figure 3-33) includes a Model 2001 to measure each DUT at two different bias levels that are provided by a Model 230 voltage source. With the source set to the first voltage level, the ten channels are scanned and measured. The source is then set to the second voltage level and the ten channels are again scanned and measured.

Since this example uses an instrument that does not have Trigger Link (Model 230), the Model 8502 Trigger Link Adapter is required. Connections are shown in Figure 3-34.

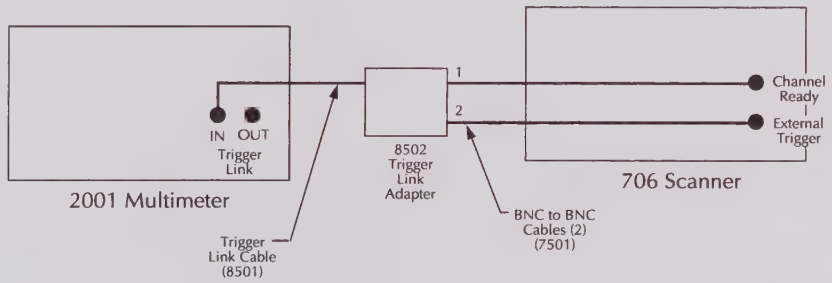


Figure 3-32
Connections using Trigger Link adapter

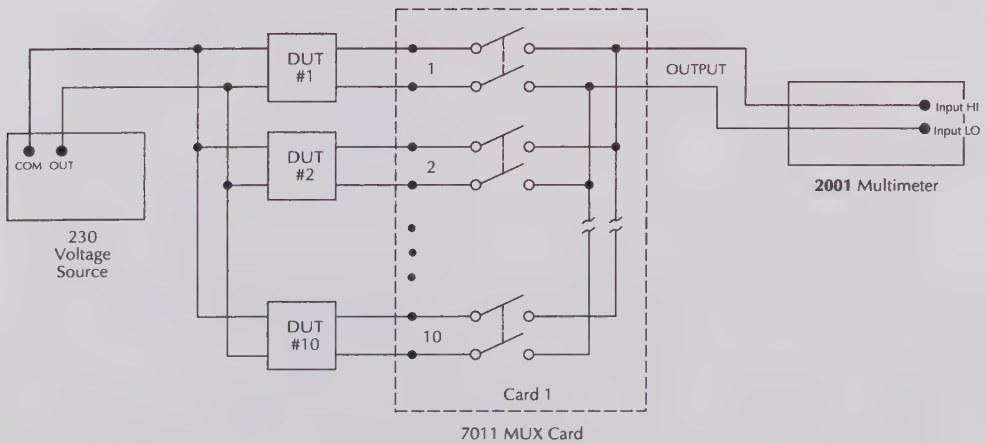


Figure 3-33
DUT test system (asynchronous example #2)

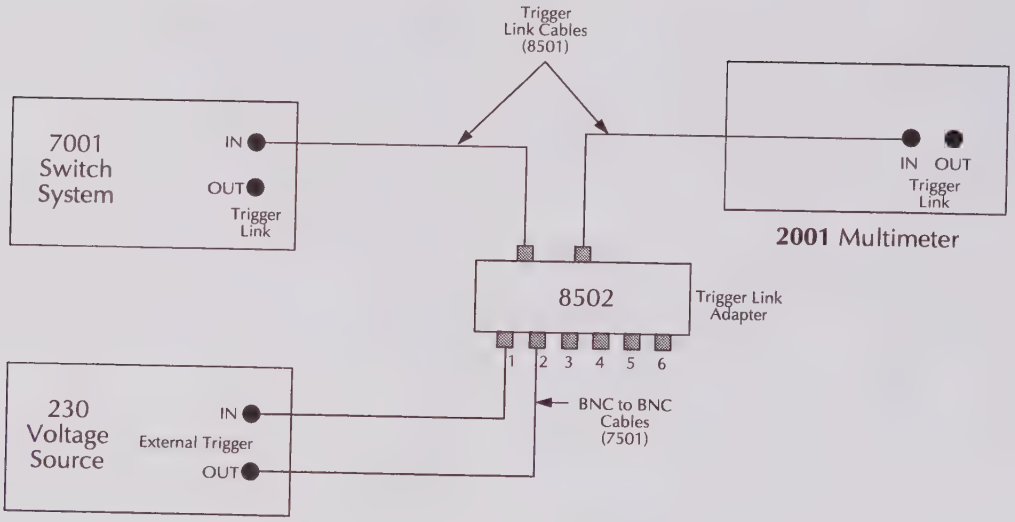


Figure 3-34
Trigger Link connections (asynchronous example #2)

For this example, the Model 230 is programmed for External Triggering and is set to source the first voltage level. The Models 2001 and 7001 are configured as follows:

Model 2001:

Idle state:

Bench reset = :INIT:CONT ON*

Arm layer:

Arm source = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:

Scan source = Immediate*
Scan count = Infinite*
Scan trigger control = Acceptor*

Measure layer:

Measure source = TrigLink
Trigger link mode = Asynchronous
Input line = #3
Output line = #4
Measure count = 20
Measure trigger control = Acceptor*

* Indicates that the setting is the BENCH RESET (and factory) default condition.

Model 7001:

Idle state:

Reset = :INIT:CONT OFF*
Scan list = 1!1-1!10,

Arm layer:

Arm spacing = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:

Scan spacing = TrigLink
Trigger link mode = Asynchronous
Input line = #2
Output line = #1
Number of scans = 2
Scan trigger control = Source

Channel layer:

Channel spacing = TrigLink
Trigger link mode = Asynchronous
Input line = #4
Output line = #3
Number of channels = 20
Channel trigger control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that the Model 2001 is reset to BENCH defaults. With this selection, the multimeter stays armed. Since the arm source and scan source are set to Immediate, the Model 2001 waits in the measure layer for a trigger.

To run the test and store the readings in the Model 2001, press STORE on the multimeter, enter the desired number of readings (20), and press ENTER. The Model 2001 waits (with the asterisk annunciator lit) for a Trigger Link trigger from the Model 7001.

Press STEP on the Model 7001 to start the scan. The following explanation on operation is referenced to the operation model shown in Figure 3-35.

(A) Pressing STEP on the Model 7001 takes it out of the idle state and places operation at point A in the flowchart. Since the arm layer is programmed for Immediate Spacing, operation drops down to the scan layer at point A.

(B) Since Scan Trigger Control of the Model 7001 is set for Source, the scan does not wait at point A for a trigger. Instead, it bypasses "Wait for Trigger Link Trigger" and proceeds to point B. Note that this Bypass is in effect only on the first pass through the model.

(C) Since Channel Trigger Source of the Model 7001 is also set to Source, the scan does not wait at point B for a trigger. Instead, it bypasses "Wait for Trigger Link Trigger" and closes the first channel (point C). Note that the Bypass is in effect only on the first pass through the model.

(D) After the relay settles, the Model 7001 outputs a Trigger Link trigger pulse (point D). Since the instrument is programmed to scan ten channels, operation loops back up to point B, where it waits for an input trigger. Note that Bypass is no longer in effect.

(E) The trigger pulse from the Model 7001 triggers the Model 2001 to make a measurement of DUT #1. After the measurement is complete, the multimeter outputs a Trigger Link trigger pulse (point E).

The trigger applied to the Model 7001 from the Model 2001 closes the next channel in the scan, which in turn triggers the multimeter to measure the next DUT. This process continues until all ten channels are scanned and measured.

(F) After the last channel is scanned and measured, operation proceeds to point F, where the Model 7001 outputs a trigger pulse. Since the Model 7001 is programmed to perform two scans, its operation loops back up to point A, where it waits for an input trigger. Note that Bypass is no longer in effect.

(G) The trigger pulse from the Model 7001 triggers the Model 230 to output the next programmed voltage level. After the voltage level is set, the Model 230 outputs a trigger pulse (point G).

The trigger pulse applied to the Model 7001 from the Model 230 places operation at point B. The Bypass is again in effect because this is the beginning of a new scan. This allows operation to drop down to point C, where the first channel is again closed and eventually measured. As previously explained, all ten channels are scanned and measured.

After the last channel of the second scan is closed and measured, the Model 7001 returns to the idle state.

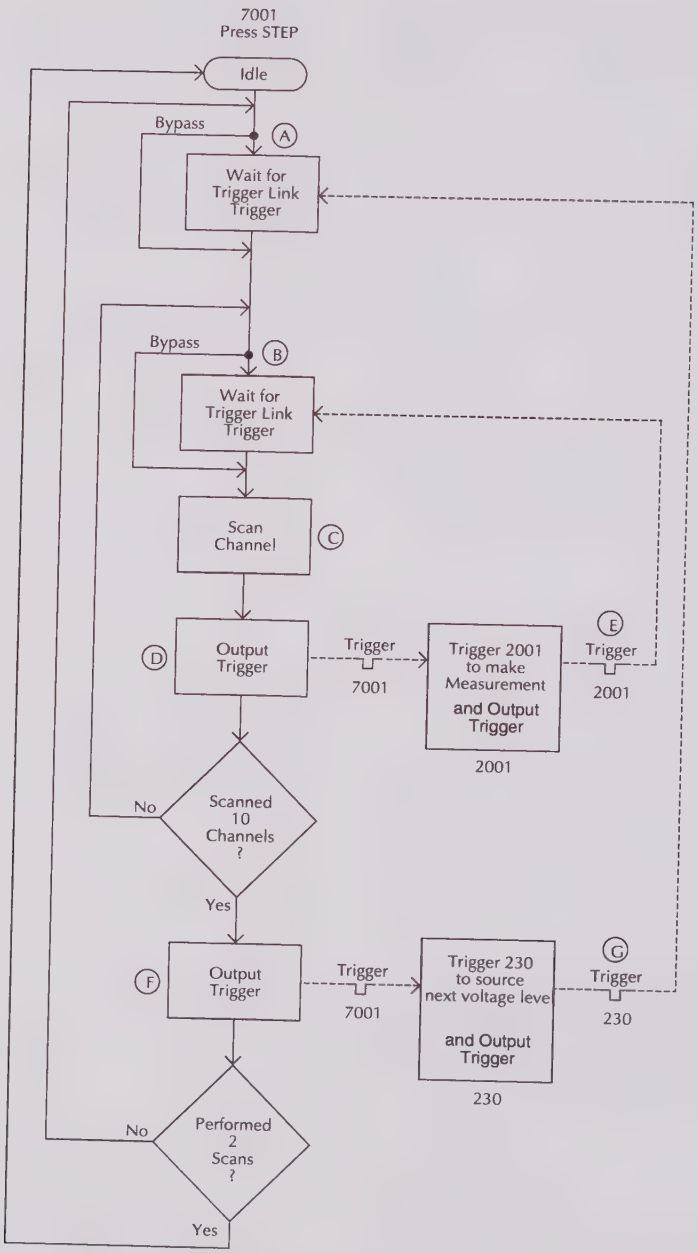


Figure 3-35
Operation model for asynchronous Trigger Link example #2

Semi-synchronous operation

In the Semi-synchronous Trigger Link mode, all triggering (input and output) is controlled by a single line. When the normally high (+5V) trigger line is pulled low (0V), a trigger occurs on the negative-going edge. When the trigger line is released, a trigger occurs on the positive-going edge (see Figure 3-36). The advantage of this single line trigger is that as long as one of the instruments in the system holds the line low, the trigger is suppressed. In other words, the trigger does not occur until all instruments in the system are ready.

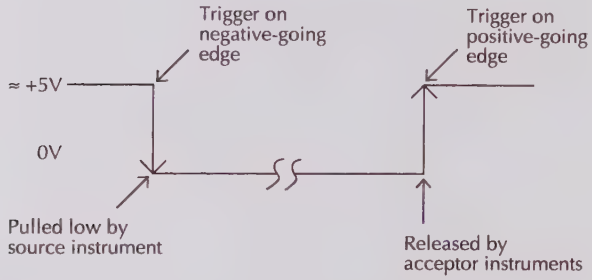


Figure 3-36
Semi-synchronous Trigger Link specifications

For example, assume that a Model 2001 is connected to two Model 7001 Switch Systems for semi-synchronous operation, as shown in Figure 3-37. All three instruments are programmed to use trigger line #1. The two Model 7001s have relay settling times of 10msec and 50msec, respectively. The Model 2001 is designated as the trigger control source and the two Model 7001 units as trigger control acceptors.

Assume that the Model 2001 initially performs a measurement. After the reading is done, the Model 2001 drives the trigger line low. The negative-going edge triggers both Model 7001s to close a channel. While the Model 7001s are in the process of closing a channel, they hold the trigger line low. Ten milliseconds after switch closure, the first Model 7001 releases the trigger line. However, the second Model 7001 continues to hold the line low since it is not finished. Fifty milliseconds after switch closure, the second Model 7001 releases the trigger line. The positive-going edge triggers the Model 2001 to make a measurement and subsequently pull the trigger line back down to close the next channels. This process continues until all channels are scanned and measured.

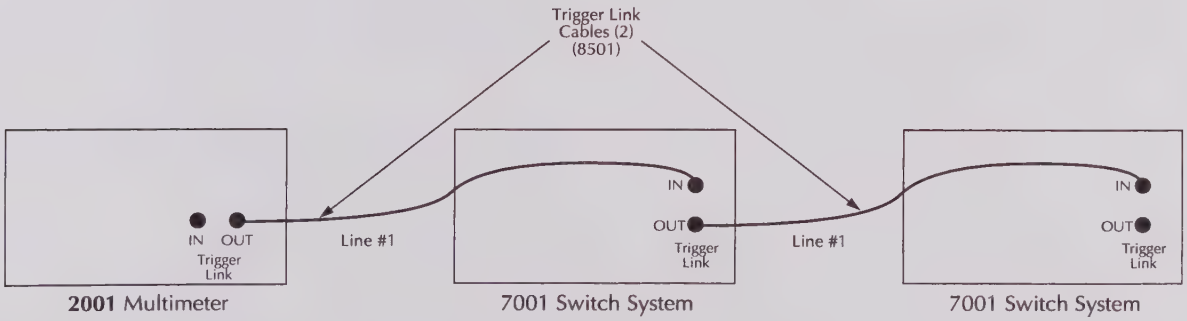


Figure 3-37
Typical semi-synchronous mode connections

Semi-synchronous Trigger Link example

This example uses the same test system (Figure 3-29) that was used for the Asynchronous Trigger Link example #1. However, triggering is done using the Semi-synchronous mode. Trigger Link connections are shown in Figure 3-38.

The two instruments are configured as follows:

Model 2001:

Idle state:

Bench reset = :INIT:CONT ON*

Arm layer:

Arm source = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:

Scan source = Immediate*
Scan count = Infinite*
Scan trigger control = Acceptor*

Measure layer:

Measure source = TrigLink
Trigger link mode = Semi-synchronous
Semi-sync line = #1*
Measure count = 10
Measure trigger control = Acceptor*

* Indicates that the setting is the BENCH RESET (and factory) default condition.

Model 7001:

Idle state:

Reset = :INIT:CONT OFF*

Scan list = 1!1-1!10,

Arm layer:

Arm spacing = Immediate*
Arm count = 1*
Arm trigger control = Acceptor*

Scan layer:

Scan spacing = Immediate*
Number of scans = 1
Scan trigger control = Acceptor*

Channel layer:

Channel spacing = TrigLink
Trigger link mode = Semi-synchronous
Semi-sync line = #1
Number of channels = Use Scanlist length*
Channel trigger control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

To run the test and store the readings in the Model 2001, press STORE on the multimeter, enter the desired number of readings (ten), and press ENTER. The Model 2001 waits (with the asterisk annunciator lit) for a Trigger Link trigger from the Model 7001. Press STEP on the Model 7001 to start the scan.

The following explanation on operation is referenced to the operation model shown in Figure 3-39.

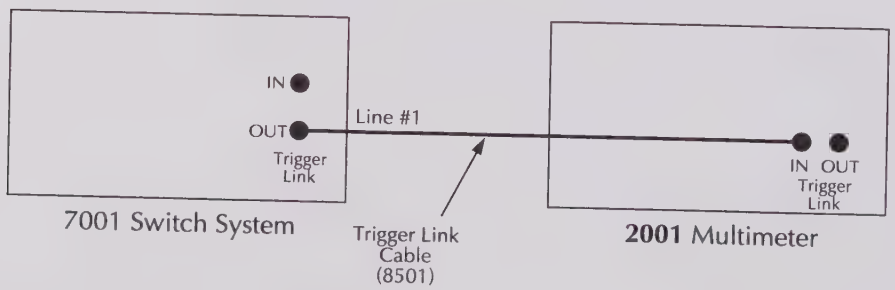


Figure 3-38
Trigger Link connections (semi-synchronous example)

(A) The BENCH RESET condition arms the Model 2001 and places multimeter operation at point A in the flowchart, where it is waiting for a Trigger Link trigger. Note that since both the arm layer and scan layer are programmed for Immediate Source, operation immediately drops down to the measure layer at point A.

(B) Pressing STEP takes the Model 7001 out of the idle state and places operation at point B in the flowchart. Since both the arm layer and scan layers are programmed for Immediate Spacing, operation drops down to the Channel Layer at point B.

(C) Since Channel Trigger Source is set to Source, the scan does not wait at point B for a trigger. Instead, it bypasses "Wait for Trigger Link Trigger" and closes the first channel (point C). Note that the Bypass is in effect only on the first pass through the model.

(D) After the relay settles, the Model 7001 pulls down the Trigger Link trigger line (point D). Since the instrument is programmed to scan ten channels, operation loops back up to point B, where it waits for an input trigger. Note that Bypass is no longer in effect.

(E) and (F) Remember that the Model 2001 operation is at point A waiting for a trigger. When the trigger line is pulled low by the Model 7001, the leading negative-going edge triggers the Model 2001 to measure DUT #1 (point E). Note that the multimeter holds the trigger line low. After the measurement is complete, The Model 2001 releases the trigger line (point F) and then loops back to point A where it waits for another input trigger.

When the Model 2001 releases the trigger line, the leading positive-going edge triggers the Model 7001 to close the next channel in the scan. This pulls the trigger line low, triggering the Model 2001 to measure the next DUT. The process continues until all ten channels are scanned and measured.

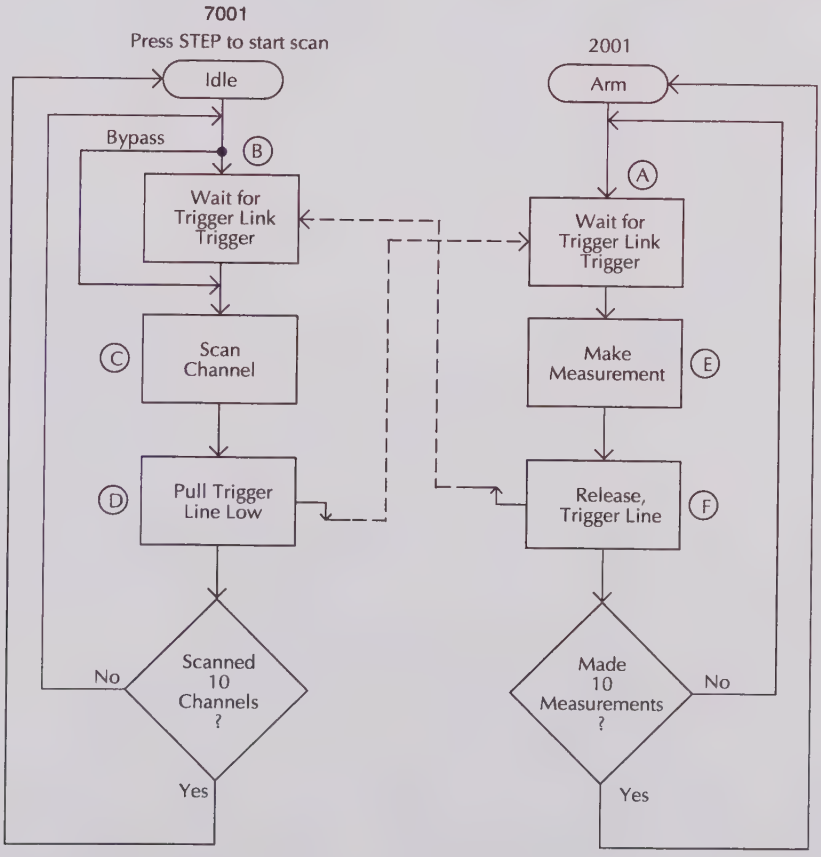


Figure 3-39
Operation mode for semi-synchronous Trigger Link example

3.8 Buffer

The Model 2001 has a buffer to store reading data. It can acquire readings at two different rates (normal and burst modes). The maximum possible number of stored readings depends on the installed memory option and the user-programmable data group. (See Table 3-29.)

Table 3-29
Reading storage options

Memory	Data group		
	Full	Compact	Type
Standard	250	850	Volatile
MEM1 option	1400	7000	Non-volatile
MEM2 option	6000	30000	Non-volatile

A full data group includes the readings, units, channel#, reading#, time-stamp, and status (overflow). A compact data group does not include channel# or time-stamp information. In addition to these items, recalled data also includes statistical information, such as minimum, maximum, average, and standard deviation.

The following paragraphs discuss configuration of the buffer acquisition speed, data grouping, and buffer control, as well as recalling buffered data. The CONFIG DATA STORE menu structure is shown and summarized in Table 3-30.

3.8.1 Burst mode

The burst data acquisition mode maximizes the reading rate of the Model 2001. Burst mode consists of two distinct phases:

- Acquiring raw readings (A/D counts).
- Post-processing the raw readings by applying calibration constants and storing the resulting readings in the buffer.

In burst mode, the Model 2001 acquires 4.5-digit readings at 2000 readings/second. The post-processing takes about 2msec/reading. If any filter or math operations are enabled, the post-processing time is longer. To make this reading rate possible, certain tradeoffs are made with the unit's functionality, as described in the following paragraph.

Table 3-30
CONFIG DATA STORE menu structure

Menu item	Description
Burst-mode	Acquire 4.5-digit readings at 2000 readings/sec and store in buffer.
Data-group	Select data types to store in buffer.
Full	Store reading, units, channel#, reading#, time-stamp, and status (overflow).
Compact	Store reading, units, reading#, and status (overflow).
Control	Select type of buffer control.
Fill-and-stop	Fill buffer with readings and stop.
Pretrigger	Wait for pretrigger event; store before and after readings.
Percentage	Enter percentage of stored readings before trigger.
Reading-count	Enter count of stored readings before trigger.
Event	Select source for pretrigger event.
Continuous	Store readings in buffer continuously.
Never	Readings are not stored.
Clear-all	Clear all stored readings and buffer statistics.
Count	Select buffer size.
Enter-count	Enter number of readings to store.
Use-trigger-model	Use (finite) measure count from trigger model.
Feed	Select type of reading to store.
After-calc	Store readings after percent or mX+b calculation.
Before-calc	Store readings before percent or mX+b calculation.

Configuring the unit for burst mode

Before burst mode can be enabled, the following changes must be made to the present instrument configuration:

- Select a valid measurement function for the burst mode, as listed in Table 3-31.
- Select a fixed range for the expected signal, or choose autorange to let the instrument select a fixed range when burst mode starts.
- Set the trigger event source in the measure layer to immediate, external, trigger link, or timer.
- Disable any "multiple displays".
- Disable scanning.

If these changes are not made, a "Settings conflict" error or similar message is displayed when you attempt to turn on burst mode.

When burst mode is selected, the Model 2001 is automatically configured for taking fast measurements. (The instrument's previous settings are restored when burst mode is aborted.) Selecting burst mode makes these temporary changes:

- Triggers are idled between bursts.
- Autoranging is disabled.
- Autozero is disabled.
- Integration time is set to 0.01 PLC (167µsec).
- Resolution is fixed at 4.5 digits.
- Buffer data group is set to compact.
- Buffer control is set to fill-and-stop.

NOTE

Some instrument settings allowed in burst mode, such as a trigger event source of timer in the measure layer, may affect the acquisition speed of 2000 readings/second.

Table 3-31
Available functions in burst mode

Function	Type
DC voltage	Normal
AC voltage	RMS, average
DC current	Normal
AC current	RMS, average
2-wire resistance	Normal

Enabling burst mode

Once burst mode is enabled, the instrument is dedicated to that purpose. Other than setting the buffer size, you cannot change any configuration parameters until burst mode is aborted. Burst mode is enabled through the CONFIG DATA STORE menu, as follows:

1. Configure the instrument's function, range, and triggering to be compatible with burst mode.
2. Display the CONFIG DATA STORE menu by pressing the CONFIG key and then STORE. The following menu is displayed:

   CONFIG DATA STORE
   BURST-MODE DATA-GROUP CONTROL ▶
   ◀ CLEAR-ALL COUNT FEED

3. Use the cursor keys (◀ and ▶) to highlight BURST-MODE and press ENTER. After a message about the enabling of burst mode clearing the buffer, the display reads:

   BURST MODE
   OFF ON

4. Select ON and press ENTER. If the instrument configuration is compatible with burst mode, this action puts the unit into idle, and takes it out of autorange. The following typical message is shown:

   BURST:00100 READINGS

   NOTE

   If the error message "Settings conflict" is displayed, the configuration of the instrument is incompatible with burst mode. The configuration must be changed to use burst mode.

5. Use the cursor and RANGE ▲ and ▼ keys to choose the buffer size. Press ENTER when done to view the following typical message:

   00100 READING BURST
   Use TRIG to start; EXIT to abort

Burst mode operation

Table 3-32 details the sequence of steps during burst mode. The steps assume just one burst of readings before aborting the burst mode, but you are able to initiate more than one burst, each time overwriting the previously stored readings.

As can be seen from the table, a front panel trigger starts the burst acquisition. The Model 2001 remains looping in the

measure layer of the trigger model until the requested number of readings is acquired. To enhance burst acquisition speed, the front panel is not updated until the raw readings are being post-processed.

Meter Complete output pulses are sent at the rate of 2kHz during the acquisition phase. (Note: The last one is not sent until post-processing is done.)

After the acquisition phase, the unit returns to the idle state and starts post-processing, which consists of converting the raw readings into measurements by applying the calibration constants. During the post- processing phase, the front panel "*" annunciator is lit.

The acquisition phase of burst mode can be aborted by pressing the EXIT key. Then the Model 2001 starts post-processing on that portion of the reading buffer.

Since burst mode turns off autozero, an autozero refresh is required once every 24 hours (by changing functions, resolution, or issuing an autozero bus command).

Table 3-32
Burst mode sequence

Action	Result	Annunciators
BURST MODE ON		
ENTER	BURST:00100 READINGS Use ◄ ,► , ▲, ▼, ENTER, EXIT, or INFO	ARM and AUTO off
ENTER	00100 READING BURST Use TRIG to start; EXIT to abort	
TRIG	(burst readings acquired)	ARM on
	(post-processing of readings) BURST:00100 READINGS Processing rdg #xx of 1000	* on
	BURST:00100 READINGS Storage complete; press RECALL	ARM and * off
	BURST:00100 READINGS Use ◄ ,► , ▲, ▼, ENTER, EXIT, or INFO	
RECALL	Rdg#+00000 ... Rdg#+00099	
EXIT	BURST:00100 READINGS Use ◄ ,► , ▲, ▼, ENTER, EXIT, or INFO (press ENTER to loop back to start)	
EXIT	BURST MODE ABORTED Use CONFIG → STORE to resume (normal reading display)	ARM and AUTO on

Notes:
1. This table assumes the unit was set for autorange before enabling burst.
2. Multiple displays of buffered readings are available when burst data is recalled. (See paragraph 3.5.4.)

3.8.2 Configuring data storage

The data storage configuration menu is used for the following operations:

- To acquire a burst of readings at high speed.
- To select the data types stored in the buffer.
- To select the buffer control.
- To clear the buffer of readings and statistics.
- To specify the number of readings to store.
- To specify the source of readings to be stored.

Perform the following steps to display the CONFIG DATA STORE menu:

1. From the normal reading display, press the CONFIG key, and then the STORE key. The following menu is displayed:

   CONFIG DATA STORE
   BURST-MODE DATA-GROUP CONTROL ▶
   ◀ CLEAR-ALL COUNT FEED

2. Use the cursor keys (◀ and ▶) to highlight the appropriate item and press ENTER to select it.

BURST-MODE

The burst mode is discussed in paragraph 3.8.1.

DATA-GROUP

This menu selection chooses the data items that are stored in the buffer. To select it, highlight it with the cursor and press ENTER. The following menu is displayed after a message about changing the data group clearing the buffer:

BUFFER DATA GROUPING
FULL COMPACT

FULL: With this selection, for each reading, the following information is stored: units, channel number (if applicable), reading number, time-stamp, and status (overflow). The first reading stored has a time-stamp of zero seconds; subsequent readings are referenced to it.

The "full" data group should be used for 6.5 digits or greater resolution. It also allows you to change function, range, or channel while storing.

COMPACT: With this selection, readings, units, reading numbers, and status (overflow) are stored. This allows more readings to be stored in the buffer.

"Compact" is only accurate and displayed to 5.5 digits. It does not allow changes of function, range, or channel while storing.

CONTROL

This menu item controls the type of data storage. It is selected by highlighting it with the cursor and pressing ENTER. The following menu is shown:

BUFFER CONTROL
FILL-AND-STOP PRETRIGGER ▶
◀ CONTINUOUS NEVER

FILL-AND-STOP: This control selection fills the buffer with the requested number of readings and stops. You can then recall the readings.

PRETRIGGER: This selection continuously stores readings until a user-programmed trigger event occurs. It then stores post-trigger readings. For example, with a buffer size of 100 readings, there will be 50 readings stored before the trigger event and 50 readings stored after the trigger.

The first reading after the trigger is reading zero. Pretrigger readings have reading numbers and time-stamps with a minus sign; post-trigger readings have reading numbers and time-stamps with a plus sign.

Pretrigger control must be further configured. Selecting it displays the following menu:

CONFIGURE PRETRIGGER
PERCENTAGE READING-COUNT EVENT

Percentage and reading-count specify the number of readings to store before the trigger event, either as a percentage of the total number of readings, or as a number of pretrigger readings.

Event selects the source of the pretrigger, or "mark point" event. This can be a Manual, GPIB, Trigger Link, or external trigger.

CONTINUOUS: With this control selection, readings are always stored in the buffer. The process continues, with the oldest readings being overwritten in a circular manner, until storage is interrupted with the EXIT key.

NEVER: Gets set to this if data storage has been interrupted. Pressing the STORE key changes NEVER to FILL-AND-STOP.

CLEAR-ALL

This action can be used at any time to clear the data buffer of all stored readings and buffer statistics. Since the MEM1 and MEM2 memory options are non-volatile, clear-all is the only way for the operator to clear the reading buffer.

COUNT

With this menu selection, you specify the number of readings to store. Highlighting it and pressing ENTER yields the following display:

```
SET BUFFER SIZE
ENTER-COUNT   USE-TRIGGER-MODEL
```

ENTER-COUNT: This item allows you to specify the buffer size in number of readings.

USE-TRIGGER-MODEL: This selection lets you default to the measure count in the present trigger configuration, as long as the measure count is a finite value.

FEED

This selection allows you to select the source of readings to be placed in the buffer. It has the following submenu:

```
CHOOSE BUFFER FEED
AFTER-CALC   BEFORE-CALC   NONE
```

AFTER-CALC: With this item, readings are stored in the buffer after any enabled math operations are performed (mX+b or percent).

BEFORE-CALC: With this item selected, readings are placed in the buffer before any math is performed (mX+b or percent).

NONE: With NONE selected, no readings are placed in the buffer when storage is performed. Pressing the STORE key changes NONE to the AFTER-CALC selection.

3.8.3 Storing and recalling readings

Tables 3-33 through 3-35 detail the sequence of steps for the various modes of buffer control. The tables assume the buffer is configured as explained in paragraph 3.8.2.

Note that during data storage, the reading number on the bottom line of the display is one ahead of the reading on the top line.

There are "multiple displays" available when recalling buffered readings. These are explained in paragraph 3.8.4.

Table 3-33
Fill-and-stop sequence

Action	Result	Annunciator
STORE	STORE 00100 READINGS	
ENTER	Storing reading #xx of 100	(* on)
	Storage complete; press RECALL	(* off)
RECALL	Rdg#+00000 @Time=+000.000000 sec	
	...	
	Rdg#+00099 @Time=+002.700473 sec	
EXIT	(normal reading display)	

Table 3-34
Pretrigger sequence

Action	Result	Annunciator
STORE	STORE 00100 READINGS	
ENTER	Waiting for pretrigger event	(* on)
TRIG	Storing reading #xx of 50	
	Storage complete; press RECALL	(* off)
RECALL	Rdg#-00050 @Time=-004.999990 sec	
	...	
	Rdg#+00000 @Time=+000.000000 sec	
	...	
	Rdg#+00049 @Time=+004.899996 sec	
EXIT	(normal reading display)	

Note: A manual trigger is used as an example. Other pretrigger events include GPIB, trigger link, and external.

Table 3-35
Continuous sequence

Action	Result	Annunciator
STORE	STORE 00100 READINGS	
ENTER	Storing reading #xx of 100	(* on)
	100 rdgs stored; continuous ON	
RECALL	Rdg#+00000 @Time=+003.903546 sec	
	...	
EXIT	100 rdgs stored; continuous ON	
RECALL	Rdg#+00000 @Time=+067.709331 sec	
	...	
EXIT	100 rdgs stored; continuous ON	
EXIT	STORAGE INTERRUPTED	(* off)
	Acquired 100 of 100 readings	
	(normal reading display)	

3.8.4 Buffer multiple displays

Math operations performed on buffered readings are available when readings are recalled. Just press NEXT DISPLAY to view the math operation on the bottom line of front panel display, in the following order:

1. MAX — maximum reading in buffer, for example:

   MAX=+1.635968e+00 at RDG# +00090

   Notes:

   A. Display response may be slow due to calculation of statistics for large buffers.

   B. Exponents are in terms of primary units of function on top line (i.e., volts, not millivolts).

2. MIN — minimum reading in buffer, for example:

   MIN=+1.627611e+00 at RDG# +00012

3. AVG — This math operation displays the mean value of the buffered readings, for example:

   AVG=+1.6345e+00

The equation used to calculate the mean is:

$$y = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: x_i is a stored reading, and
n is the number of stored readings.

Note: If n = 0, the result is NAN (not a number).

4. SDEV — This operation displays the standard deviation of the stored readings, for example:

SDEV=1.4944e-03

The equation used to calculate the standard deviation is:

$$y = \sqrt{\frac{\sum_{i=1}^{n} X_i^2 - \left(\frac{1}{n}\left(\sum_{i=1}^{n} X_i\right)^2\right)}{n-1}}$$

where: x_i is a stored reading, and
n is the number of stored readings.

Note: If n ≤ 1, the result is NAN (not a number).

NOTE

These statistics are invalid if the measurement function changed during data store (e.g., when scanning different functions).

NOTE

The Model 2001 uses IEEE-754 floating point format for math calculations.

The last display in this series allows you to dump the buffered readings to a printer. See paragraph 3.12.2 for details on configuring printers.

3.9 Filters

Filtering stabilizes noisy measurements. The Model 2001 uses a digital filter and an analog filter.

The digital filter is based on reading conversions. The displayed, stored or transmitted reading is simply an average of a number of reading conversions. When the digital filter is enabled, the selected digital filter configuration for that measurement function is in effect. Digital filtering is performed only on primary display measurements; it has no effect on multiple displays. Paragraphs 3.9.1 through 3.9.6 explain how to configure and control the digital filter.

The analog filter is simply an RC network for the DCV function that filters out high frequency noise (>10kHz) seen at the input of the instrument. Detailed information on using the analog filter is contained in paragraph 3.9.7.

3.9.1 Digital filter types

The Model 2001 has two types of digital filters: averaging and advanced. Both types are a simple average of one to 100 reading conversions. The difference between them is the user-programmable noise "window" of the advanced filter.

The noise window, which is expressed as a percentage of range (0-100%), allows a faster response time to large signal step changes (e.g., scanned readings). A reading conversion outside the plus or minus noise window fills the filter "stack" immediately.

If the noise does not exceed the selected percentage of range, the reading is based on an average of reading conversions. In this case, the advanced filter works the same as the averaging filter. If the noise does exceed the selected percentage, the reading is a single reading conversion, and new averaging starts from this point. The two filter types are compared in Figure 3-40A.

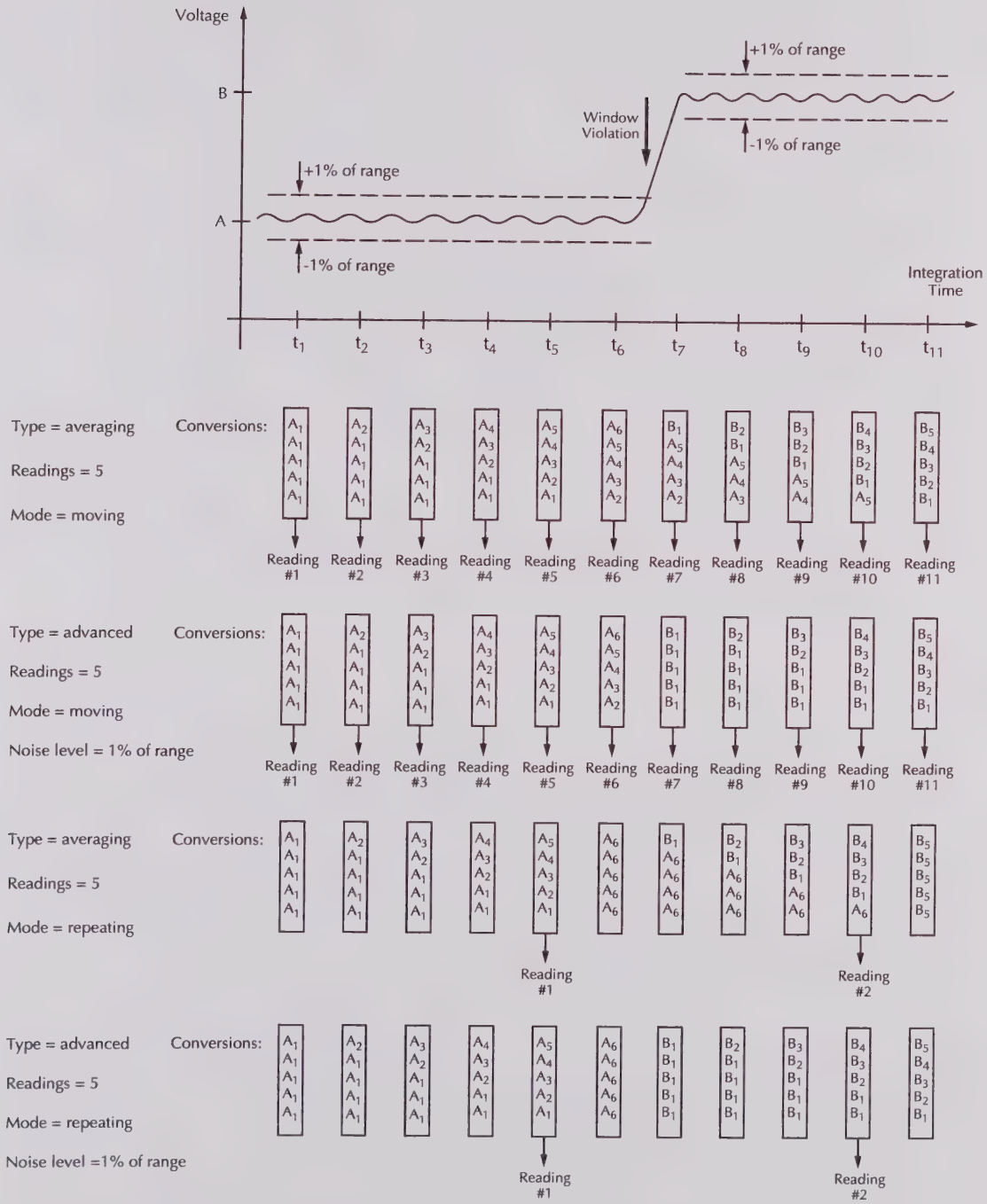
3.9.2 Digital filter modes

An additional filter parameter is the mode, either moving or repeating. A moving filter is a first-in, first-out stack, where the newest reading conversion replaces the oldest. An average of the stacked reading conversions yields a reading. Therefore, after a selected number of conversions, a moving filter gives a new reading for every new conversion.

A repeating filter takes a selected number of reading conversions, averages them, and yields a reading. It then flushes its stack and starts over. This characteristic is useful when scanning channels.

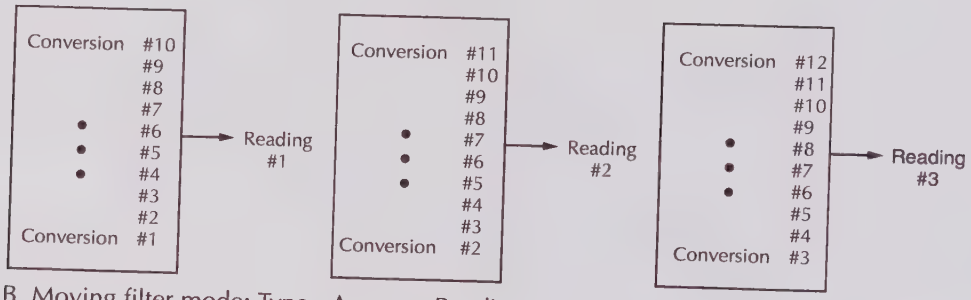
If burst mode is enabled with filtering, the post-processing time increases. A filter mode setting of repeating is ignored in burst mode.

Filter modes are compared in Figures 3-40B and 3-40C.

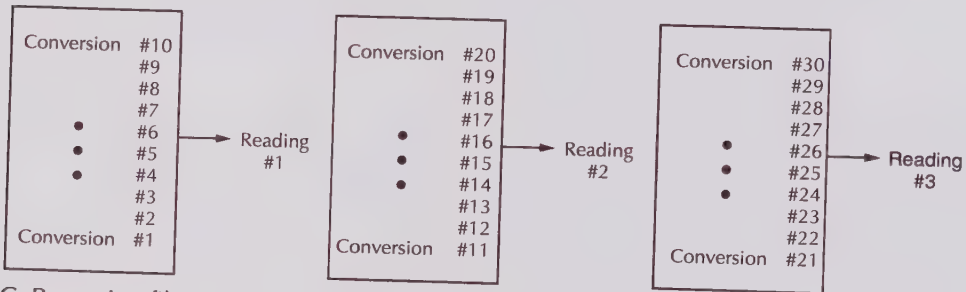


A. Averaging and advanced filter types

Figure 3-40
Digital filter



B. Moving filter mode; Type - Average, Readings = 10



C. Repeating filter mode; Type - Average, Readings = 10

Figure 3-40 (cont.)
Digital filter

3.9.3 Response time (Digital filter)

The various filter parameters have the following effects on the time needed to display, store, or output a filtered reading:

- Filter type: The time to the first reading is the same for both types, but thereafter averaging mode yields a faster reading than repeating mode. Also, advanced has a faster response to changes in the input signal than averaging.
- Number of reading conversions: Speed and accuracy are tradeoffs.
- Noise window: For the advanced type, a tradeoff of speed, accuracy, and response to input signal changes.

3.9.4 Auto filtering (Digital)

For those measurement functions with a filter, one of the possible selections is automatic filtering. Depending on the measurement function and type, the AUTO selection may disable filtering. Auto filtering is summarized in Table 3-36.

3.9.5 Configuring the digital filter

Each measurement function except frequency has its own configuration for a digital filter. A digital filter configuration menu is shown in Table 3-37.

Table 3-36
Auto filters

Measurement		Filter				
Function	**Type**	**State**	**Type**	**Readings**	**Averaging Mode**	**Noise Tolerance Level**
DC voltage	--	On	Advanced	10	Moving	1%
AC voltage	RMS, average, low frequency RMS	Off	Advanced for volts; Average for dB, dBm	10	Moving	5%
	Peak, pos. peak spikes, neg. peak spikes	On	Advanced for volts; Average for dB, dBm	10	Moving	5%
DC current	Normal	On	Advanced	10	Moving	1%
	In-circuit	On	Advanced	10	Moving	1%
AC current	RMS, average	Off	Advanced	10	Moving	5%
2-wire resistance	--	On	Advanced	10	Moving	1%
4-wire resistance	--	On	Advanced	10	Moving	1%
Frequency	--	*				
Temperature	--	On	Average	10	Moving	-

*Note: A filter is not available on the frequency function.

Table 3-37
CONFIG-FILTER menu structure

Menu item	Description
Auto	Default to filter appropriate for measurement function and type.
Averaging	Program simple average filter (1-100 readings).
Advanced	Program simple average filter (1-100 readings), with a noise tolerance window (0-100% of range).
Averaging-mode	Select moving average or repeating average mode.

Choosing the filter parameters for each function follows the same procedure. You can program a digital filter as follows:

1. There are three ways to display a filter configuration menu:
   - To configure the filter of the present function, just press CONFIG, then FILTER.
   - To configure the filter of another function and remain in the present function, press CONFIG, and the appropriate function key, then select FILTER from its menu.
   - To configure the filter of another function and change to that function, press the appropriate function key, and CONFIG, then FILTER.
2. As an example, consider the DCV digital filter menu. Display the CONFIGURE DCV menu by pressing the CONFIG key and then the DCV key.
3. Use the cursor keys (◄ and ►) to place the cursor on FILTER and press ENTER to access the following menu:

DCV DIGITAL FILTER
AUTO AVERAGING ADVANCED ►
◄ AVERAGING-MODE

AUTO

This menu item selects auto filtering. When chosen, auto filtering enables the filter parameters listed in Table 3-17 for the function you are presently configuring. Note that selecting AUTO immediately enables the filter for that function when the state listed in Table 3-17 is ON. In this case, if you are configuring the filter for the present measurement function, the FILT annunciator comes on.

AVERAGING

Use this selection for a non-windowed averaging filter. A message indicating the presently set number of reading conversions to average (the "stack" size) is displayed:

AVG:010 RDGS (1-100)

1. To retain the displayed number, press ENTER or EXIT.
2. To set a different number, use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits. Press ENTER when done.

   Note that the number of reading conversions selected for the averaging filter type is coupled to that for the advanced filter type.

ADVANCED

This selection is for an averaging filter with a noise window. (It is not available with dB or dBm units, ratio or delta, temperature or frequency.) A message indicating the presently set number of reading conversions to average (the "stack" size) is displayed:

ADV:010 RDGS (1-100)

1. To retain the displayed number, press ENTER. To set a different number, use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits. Press ENTER when done.

   Note that the number of reading conversions selected for the advanced filter is coupled to that for the averaging filter.
2. The next message is for the maximum noise window, which is expressed in percent of range, as follows:

   LEVEL = 00.000000%RNG

   This is the plus or minus percentage of range window around the first reading conversion in the stack. To set a different percentage, use the cursor keys and RANGE keys. Press ENTER when done.

AVERAGING-MODE

This selection determines the mode of a digital filter for a measurement function, either a moving or repeating average. The AVERAGING MODE menu is shown as follows; its present selection is highlighted:

AVERAGING MODE
MOVING REPEAT

MOVING: This item selects a moving filter, where a new reading conversion is shifted into a stack as the oldest conversion is shifted out (FIFO). When the stack is full, a simple average is taken to yield a reading.

REPEAT: This menu item selects a repeating filter, where an average of a selected number of reading conversions is taken for each reading.

3.9.6 Enabling/disabling the filter

The FILTER key toggles the filter on and off for the present measurement function. With the FILT annunciator on, the filtering action depends on the selections chosen in the FILTER menu for the present function. With the FILT annunciator off, the digital filter for that function is completely disabled.

The state and configuration of the digital filter for each function is saved when changing functions.

- Pressing the FILTER key to enable the filter momentarily displays one of the following typical messages:

  Filter Enabled
  Digital = AVG(10)

  or

  Filter Enabled
  Digital = ADV(10)

  or

  Filter Enabled
  Digital = AUTO

where: AVG is the averaging filter.
ADV is the advanced filter.
AUTO is the type listed in Table 3-36.
(10) is the number of reading conversions to average.

3.9.7 Analog filter

The Model 2001 has an analog filter for use with the DCV function. This filter reduces the number of overflow errors caused by noise seen on the input signal. The analog filter is most effective when measuring voltages greater than 2 Vp-p frequencies ranging from 10kHz to 1MHz.

Controlling the analog filter

Perform the following steps to enable or disable the analog filter:

1. Press CONFIG and then DCV to display the DCV configuration menu.
2. Place the cursor (using ▲ and ▼ keys) on ANALOG-FILTER and press ENTER to display the control options (ON or OFF). Cursor position indicates the present state of the analog filter.
3. To change the state of the analog filter, place the cursor on the alternate state and press ENTER.
4. Use the EXIT key to back out of the menu structure.

NOTE

The FILT annunciator on the display only indicates the state of the digital filter. It is not used for the analog filter.

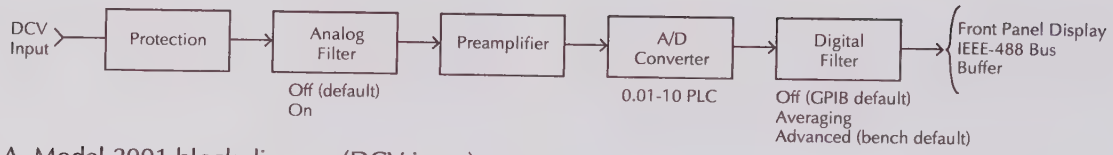
Selecting the first multiple (NEXT) display for DCV enables the analog filter. Leaving this multiple display returns the analog filter to its previous state.

Analog filter characteristics

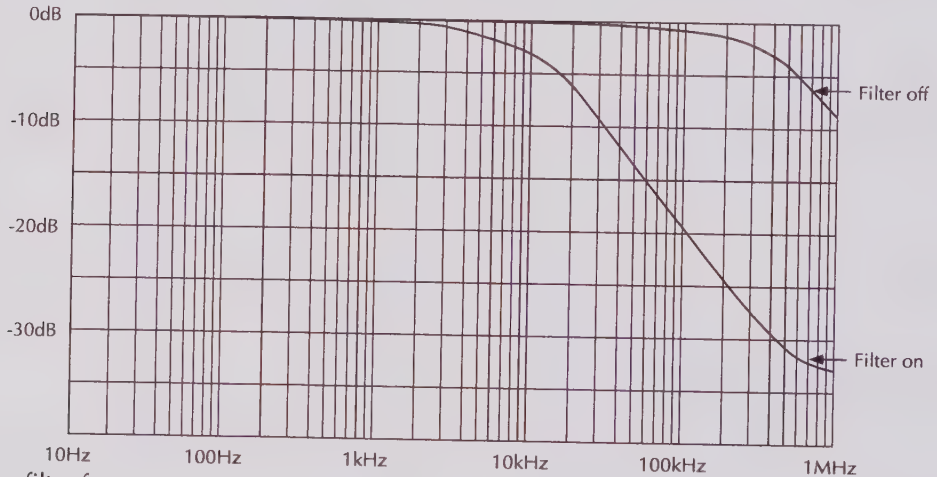
Figure 3-41A provides a simplified block diagram of the Model 2001 showing the location of the analog filter. When enabled, it provides a "cleaner" signal to the preamplifier. As a result, readings are less noisy. The analog filter does not affect any of the instrument's specifications beyond those dealing specifically with the filter function.

The analog filter is a single stage, single-pole, low-pass RC network that rolls off the signal at an approximate rate of 20dB per decade above the cutoff frequency of 10kHz. The analog filter has a zero at 600kHz. Figure 3-41B shows the general frequency response for the analog filter.

The analog filter is most effective on the 2V or 20V range with line synchronization enabled. On the 200mV range, a noisy input signal may cause overflow readings even though the analog filter is enabled.



A. Model 2001 block diagram (DCV input)



B. Analog filter frequency response

Figure 3-41
Analog filter

3.10 Math

Model 2001 math operations are divided into four categories:

- Math performed on single readings (mX+b and percent).
- Math performed on buffered readings (maximum and minimum values, average, and standard deviation).
- Math performed on single readings as a part of a pass/fail limits test.
- Math performed on scanned readings (ratio and delta).

The first category is configured from the CONFIG-MATH menu and is described in this paragraph. Math operations on buffered readings are available in multiple displays of recalled data and are discussed in paragraph 3.8. Limit tests are described in paragraph 3.12, under main menu operations. Ratio and delta calculations on scanned channels are available from the CONFIG-SCAN menu, as discussed in paragraph 3.11.

Note that once enabled for a function, the mX+b, percentage, and percent deviation calculations are in effect across function changes.

NOTE

The Model 2001 uses IEEE-754 floating point format for math calculations.

3.10.1 mX+b

This math operation allows you to automatically multiply normal display readings (X) by a scale factor (m) and add an offset (b). The result (Y) is displayed on the top line according to the formula:

$$Y = mX + b$$

The mX+b math operation is useful when slope calculations are required for a series of measurements.

The values of the "m" and "b" constants can be changed through the CONFIG-MATH menu. The before and after calculation can be viewed with one of the next displays, as described in paragraph 3.10.5. When necessary, the resulting Y value is displayed in scientific notation.

3.10.2 Percent

This operation lets you specify a target reading value. The displayed reading will be expressed as a percentage of the target value, often in scientific notation. The percentage calculation is performed as follows:

$$\text{Percent} = \frac{\text{Input Reading}}{\text{Target Value}} \times 100$$

As an example, consider the default target value for percentage calculations, where:

100% = +1.000000e+00

Therefore, on the 200µA range, a 100µA input would be 0.01% of the target value and a typical reading would be displayed as follows:

+1.0000e+04µAAC%
Range: 200 µAAC Coupling: AC

Note that the value is not 10000%, but 10000µ%, which equals 0.01%. With the calculate multiple display selected, as described in paragraph 3.10.5, the display would be:

+1.0000e+04µAAC%
Reading = +100.000

where the bottom line shows the reading (in the units and multiplier prefix of the top line) before the percentage calculation is performed.

3.10.3 Percent deviation

The following math calculation provides the percent deviation between the normal display reading and the currently stored REL value for the selected function:

$$PD = \frac{(X - Y)}{Y} \times 100\%$$

Where: X is the normal display reading
Y is the REL value for the selected function
PD is the displayed percent deviation result

Percent Deviation is enabled through the CONFIGURE MATH menu as described in paragraph 3.10.4 below.

Note that Percent Deviation does not scale based on the m, k, or M range factor. For example, 10% deviation on the 20kΩ range will be displayed as 10.00000. If the number is too large for the allowed number of leading zeroes (for example 10 on the 2kΩ range), the display will switch to 7-1/2 digit scientific notation.

3.10.4 Configuring math

The mX+b, percent, and percent deviation math operations are programmed from the CONFIGURE MATH menu. The selections are shown in Table 3-38.

To program the math parameters from the normal reading display, press the CONFIG key, and then the MATH key to access the following menu:

CONFIGURE MATH
NONE mX+b PERCENT

Table 3-38
CONFIGURE MATH menu structure

Menu item	Description
None	Select no calculation when MATH key is pressed.
mX+b	Select mX+b calculation and enter constants.
Percent	Select percent calculation and enter target (reference) value.
Percent deviation	Select percent deviation calculation.

NONE

With this menu item, no math operation goes into effect when the MATH key is pressed. The MATH annunciator lights, but NONE is displayed on the top line.

mX+b

This menu item allows you to program the mX+b constants, where m is the scale factor, and b is the offset. After highlighting the mX+b selection and pressing ENTER, the default display shows:

m = +1.000000e+00

Use the cursor (◄ and ►) and RANGE keys to move among the digits and set their desired values. Once the scale factor is configured, press ENTER to view the following default display:

b = +0.000000e+00

The cursor and RANGE keys are used to set the desired value of offset. Pressing ENTER returns you to the CONFIGURE MATH menu.

PERCENT

This selection lets you specify the target value for the percentage calculation. The default message indicating the presently set target value is displayed as follows:

100%= +1.000000e+00

1. To retain the displayed target value, press ENTER or EXIT.
2. To set a different target, use the cursor keys (◄ and ►) to select the digits, and the RANGE ▲ and ▼ keys to increment and decrement the digits. Press ENTER when done.

PERCENT DEVIATION

This menu item selects the percent deviation calculation and returns the display to the normal measurement state.

3.10.5 Enabling math

The MATH key toggles the selected math operation on and off from the normal reading display. Once a math operation is enabled, it is in effect across function changing. This is indicated by the MATH annunciator and, at the right side of the top line, the type of math enabled (NONE, mX+b, or %).

Pressing the MATH key to enable a math operation momentarily displays one of the following typical messages:

Math Enabled
Display = NONE (Reading)

or

Math Enabled
Display = mX+b (Reading)

or

Math Enabled
Display = % (Reading)

Then the Model 2001 displays the result of the calculation on the top line, using scientific notation where necessary.

3.10.6 Calculate multiple display

One of the multiple displays lets you view the reading on the bottom line of the display and the result of the calculation on the top line. This display is available by repeatedly pressing either the NEXT or PREVious DISPLAY key to scroll through the multiple displays for the particular function. The following is a typical message for a percentage calculation:

-7.0431e+01 VDC %
Reading = -0.704311

The display resolution on the bottom line follows that chosen for the top line. If scientific notation is required on the top line, it is fixed at 4.5 digits. The value on the bottom line tracks the units and prefix of the top line. (For example, if the top line displays µA, then the units on the bottom line are µA.)

Note that this multiple display is not available on the frequency function.

3.11 Scanning

The Model 2001 can be used with an internal scanner card (Model 2001-SCAN) or with external scanner cards installed in switching mainframes such as the Models 706 and 7001. The following paragraphs discuss various aspects of using scanning with the Model 2001.

3.11.1 Scanning overview

A scanner allows you to switch among a number of input signals to the Model 2001 for measurement. The channel control and scanning capabilities depend on whether an internal or external scanner card is being used, as well as on the capabilities of the scanner card in question. Refer to the documentation supplied with the scanner card for specific connection information.

Using an internal scanner card

The optional Model 2001-SCAN scanner card allows you to switch or scan up to ten 2-pole channels, or five 4-pole channels. Two of the channels use solid-state switching for high-speed multiplexing, ratio, or delta applications.

When using this card, the Model 2001 can:

- Close and open individual channels.
- Scan through channels using a separate measurement function for each channel, if desired.
- Perform ratio and delta measurements using two user-defined channels.

Using external scanner cards

When using external scanning, you can define separate measurement functions for a maximum of 80 channels. Note

however, that you cannot close or open external channels using Model 2001 controls. Use the switching mainframe controls to open and close individual channels.

In order to synchronize Model 2001 measurements with external channel closure, connect the Model 2001 external trigger inputs or the trigger link to the external switching mainframe trigger inputs and outputs. Refer to paragraphs 3.7.6 and 3.7.7 for information on using external triggering and the trigger link.

3.11.2 Front panel scanner controls

Controls that affect scanner card operation include:

- CHAN: Allows you to open and close internal scanner card channels.
- CONFIG-CHAN: Defines the measurement functions for each internal and external scanner card channel, selects the number of external channels, defines channels assigned to the internal scan list, and saves/restores an alternate measurement function.
- CONFIG-SCAN: Selects internal or external scanning and controls ratio/delta operation when using the internal scanner.
- SCAN: Starts/stops scanning using the selected scan list. Configures scan count, scan interval, and enables buffer storage and recall if internal or external list is selected.
- EXIT: Disables scanning and returns to normal operation. (Trigger model is restored to pre-scanning configuration.)
- ◄ and ► : Allows you to manually scan through channels.
- PREV/NEXT DISPLAY: Allows you to display the two adjacent channels (manual scanning only).

3.11.3 Using CHAN to close and open internal channels

CHAN key operation

The CHAN key controls channels on the internal scanner card only. The CHAN key allows you to directly:

- Close a specific channel (or channel pair for 4-wire functions).
- Immediately open any internal closed channel (or channel pair for 4-wire functions).

Channel selection menu

Table 3-39 summarizes the channel selection menu structure along with a brief description of each item. More detailed descriptions of these menu items are presented in the following paragraphs. See paragraph 3.3 for general rules on navigating menus.

Pressing CHAN will display the following menu choices:

CHANNEL SELECTION
CLOSE-CHANNEL OPEN-ALL-CHANNELS

Table 3-39
CHANNEL SELECTION menu structure

Menu item	Description
CLOSE-CHANNEL ENTER CHAN#01 (1-10) OPEN-ALL-CHANNELS	Close channel menu: Use cursor, range, and ENTER keys. Press ENTER to open closed channel(s).

CLOSE-CHANNEL: Selecting CLOSE-CHANNEL will display the following message prompting you to select the channel to close:

ENTER CHAN#01 (1-10)

The field entry after "ENTER CHAN#" indicates the channel to close. To close a channel, simply use the cursor and range keys to select the number of the channel to close, then press ENTER. The number of the closed channel will be displayed on the front panel along with normal readings.

Selecting a different channel from the one that is presently closed will cause the closed channel to open and allow a settling time before closing the selected channel.

Channel relays will be closed according to the presently selected function. If a 2-wire function is used, only the relay for that one channel will be closed. If a 4-wire function is selected, both the selected channel relay and the matching relay pair will close. For example, closing the matching relay pair will close. For example, closing channel 2 will also close the channel 7 relay. Fixed 4-pole relay pairs are:

- 1 and 6
- 2 and 7
- 3 and 8
- 4 and 8
- 5 and 10.

OPEN-ALL-CHANNELS: Selecting OPEN-ALL-CHANNELS will immediately open any closed scanner card channels or channel pair for 4-wire functions.

3.11.4 Using CONFIG-CHAN to configure channels

CONFIG-CHAN operation

CONFIG-CHAN allows you to:

- Select measurement functions for internal scanner card channels, and define which channels to use when scanning.
- Select measurement functions and the number of channels in an external scanner used with the Model 2001.
- Define, save, and restore an alternate measurement function which can then be assigned to specific channels.

CONFIGURE CHANNELS menu

Table 3-40 summarizes the CONFIGURE CHANNELS menu structure, which is discussed in detail in the following paragraphs. Again, see paragraph 3.3 for more information on navigating menus.

Pressing CONFIG then CHAN will display the following menu:

CONFIGURE CHANNELS
INTERNAL-CHANS EXTERNAL-INPUTS ▶
◀ SAVE-ALT-FCN RESTORE-ALT-FCN

INTERNAL-CHANS: The INTERNAL-CHANS selection allows you to set the measuring function for each of the internal scanner card channels. When this selection is made, the following submenu will be displayed:

SET INTERNAL CHANS
1=DCV 2=DCV 3=DCV 4=DCV 5=DCV ▶
◀ 6=DCV 7=DCV 8=DCV 9=DCV 10=DCV

With this menu displayed, use the cursor keys to select the channel, and use the range keys to select the desired measuring function for each channel:

DCV: DC volts
ACV: AC volts
Ω2W: 2-wire ohms
Ω4W: 4-wire ohms
FRQ: Frequency
TMP: Temperature
ALT: alternate function (see below)
JN1...JN5: Reference junction type
--- : None

Table 3-40
CONFIGURE CHANNELS menu structure

Menu item	Description
INTERNAL-CHANS SET INTERNAL CHANS 1=DCV 2=DCV 3=DCV 4=DCV 5=DCV	Defines internal functions: Use range and cursor keys to select channels and functions.
EXTERNAL INPUTS # EXTERNAL INPUTS=80 DEFAULT CHOOSE-FUNCTIONS SELECT CHAN=01 CHANNEL #01 FUNCTION	Sets number of external channels and functions: # of external channels (1-80). Selects default function for all external channels. Use to select channel functions. Select channel using range and cursor keys. Select function using cursor keys.
SAVE-ALT-FCN RESTORE-ALT-FUNCTION	Stores present function as alternate. Restores saved alternate function.

Ω4W function: The Ω4W function is valid only for channels 1-5. If selected, "PRD" (paired) will be shown on the corresponding paired channel 6-10 even if you just step through with the cursor keys and do not press ENTER. Once Ω4W is selected on channels 1 to 5, changing the assignment to a different function will de-assign the paired channel and change the function to "---" (none).

TMP function: Similarly, the TMP selection is valid only for channels 1-5 if the temperature sensor is a 4-wire RTD type. If a 2-wire RTD type is used, channels 6-10 could be assigned to the TMP function, but if the sensor type is later changed to 4-wire RTD, any channel from 6-10 will then be set to "---" (none).

JN functions: Note that there are five reference temperature functions available (JN1-JN5). Junction types are defined using the CONFIGURE TEMPERATURE menu.

NOTE

The JN functions in the internal menu are intended for use with a possible future internal thermocouple scanner card. The Model 2001-SCAN internal scanner card is not intended to be used with thermocouples.

No function (---): Selecting none (---) effectively removes that channel from the scan list. When scanning, the instrument will skip any channels that have no function defined.

EXTERNAL-INPUTS: This menu item allows you to select measurement functions for external scanner cards used with the Model 2001 Multimeter. When the EXTERNAL-INPUTS menu item is selected, the instrument will prompt you to enter the number of channels being used:

```
# EXTERNAL INPUTS=80
```

Use the cursor and range keys to select the number of channels (1-80), then press ENTER. Once the number of inputs is selected, you will be prompted for channel functions:

```
SET CHAN FUNCTIONS
DEFAULT   CHOOSE-FUNCTIONS
```

Briefly, these menu items allow you to select the following:

Default: This selection assigns the presently selected measurement function to all external channels.

Choose-Function: This menu choice allows you to define functions for each external channel through the following prompt:

```
SELECT CHAN= 01 (DCV)
```

Select the channel to be programmed using the range and cursor keys, then press ENTER. The instrument will display available functions:

```
CHANNEL#01 FUNCTION
DCV  ACV  DCI  ACI  Ω2W  Ω4W  FRQ  TMP ▶
◀ ALT  JN1  JN2  JN3  JN4  JN5  ---
```

Use the cursor keys to select the desired function, then press ENTER. Repeat the procedure for every external channel to be defined.

SAVE-ALT-FCN/RESTORE-ALT-FCN: An ALT (alternate) function is one that cannot be directly accessed with one of the eight function keys. For example, assume that you select the ACV peak function using CONFIG-ACV. You can then use SAVE- ALT to assign peak ACV to the ALT function. Whenever the ALT function is encountered in the scan list, the instrument will switch to the ACV peak function for that channel even if the instrument is measuring a different type of ACV (RMS for example).

You can also use the ALT function to store an existing main function but with a different set of operating parameters. For example, you could set up a specific set of operating parameters for the straight DCV function and a second DCV setup as the ALT function. This arrangement allows you to specify changes in virtually any measurement parameter from channel to channel even if the measurement functions are the same.

NOTE

Some functions may not be compatible with certain scanner cards. For example, you should not use the DCI and ACI functions with the Model 2001-SCAN internal scanner card.

SAVE-ALT-FCN: Stores the presently selected function and all its configured settings as the ALT function.

RESTORE-ALT-FCN: Restores the function that was saved as the ALT function and all associated settings as if a normal function change were taking place.

3.11.5 Using CONFIG-SCAN to configure scanning

CONFIG-SCAN operation

CONFIG-SCAN allows you to configure the following scanner aspects:

- Select the internal or external channel list for scanning.
- Enable ratio and delta operation.

SCAN OPERATION menu

Table 3-41 summarizes the SCAN OPERATION menu structure, which is discussed in more detail in the following paragraphs. See paragraph 3.3 for more information on menu navigation.

Table 3-41
SCAN OPERATION menu structure

Menu item	Description
INTERNAL	Enables internal scanning.
EXTERNAL	Enables external scanning.
RATIO	Enables ratio mode (internal).
MEASURE	Selects measure channel.
REFERENCE	Selects reference channel.
FUNCTION	Selects ratio function.
DELTA	Enables delta mode (internal).
MEASURE	Selects measure channel.
REFERENCE	Selects reference channel.
FUNCTION	Selects delta function.

Pressing CONFIG-SCAN will display the following menu:

SCAN OPERATION
INTERNAL EXTERNAL RATIO DELTA

These choices select the action the instrument will take when it is triggered.

INTERNAL: This selection enables scanning with the internal scanner card. When this selection is chosen, the Model 2001 will change to the function specified for the first channel and then close the channel and take a reading. When the next trigger is received, the instrument will open the present channel, change to the specified measuring function for the next channel, and then close the channel and take a reading. The process repeats until all channels in the list are scanned.

The instrument defaults to this selection if it detects a scanner card on power-up.

EXTERNAL: This menu selection enables scanning with an external scanner card located in a switching mainframe. This selection operates in a manner similar to INTERNAL except that the internal scanner is not used. When this menu item is selected, the instrument will immediately change to the selected measuring function for the first channel. When the multimeter is triggered, it will take a measurement and then change to the measurement function for the next channel. This process repeats until all channels in the scan list are scanned.

The instrument defaults to this selection if it does not detect a scanner card on power-up.

RATIO/DELTA: Either of these two selections configures the Model 2001 to measure the two specified internal scanner channels and then compute the ratio or difference (delta) between them. When RATIO or DELTA is selected, the instrument will close the scanner reference channel and then wait for a trigger. When the reading is triggered, the unit will make a measurement on the reference channel, switch to the measurement channel, and then take a second measurement. After measuring the measurement channel, the unit will compute and display the ratio or delta value, and switch back to the reference channel to wait for the next trigger.

RATIO/DELTA channel selection: To select channels for RATIO and DELTA, select RATIO or DELTA as appropriate.

Selecting RATIO will display the following menu and allow you to set the measure or reference channel:

CONFIGURE RATIO
MEASURE REFERENCE FUNCTION

Selecting MEASURE will display the following:

RATIO MEASURE CHAN
CH1 2 3 4 5 6 7 8 9 10

Use the cursor keys to select the measure channel, then press ENTER.

Similarly selecting REFERENCE will display:

RATIO REFERENCE CHAN
CH1 2 3 4 5 6 7 8 9 10

Again, use the cursor keys to select the channel to be used as the ratio reference channel, then press ENTER.

The FUNCTION menu appears as follows:

SET RATIO FUNCTION
DCV Ω2 Ω4

Use the cursor keys to select the desired function, then press ENTER.

Selections for DELTA measure and reference channels, and function are essentially the same, except that you would select DELTA under the SCAN OPERATION menu.

Ratio and Delta computation: During configuration, one channel is defined as the reference channel, and a second channel is defined as the measurement channel. Ratio and delta are computed from signals measured on these channels as follows:

$$\text{Ratio} = \frac{\text{Measurement}}{\text{Reference}}$$

$$\text{Delta} = \text{Measurement} - \text{Reference}$$

3.11.6 Using SCAN to configure scan parameters

Once an internal or external scan list is enabled, you use the SCAN key to configure internal or external scanning. The menu structure of Figure 3-42 shows the procedure.

The procedure changes scan layer parameters in the trigger model. When scanning is disabled by the EXIT key, the trigger model is restored to its pre-scanning configuration.

3.11.7 Starting and stopping scanning

Internal and external scanning

After an internal or external scan is configured, pressing the ENTER key from the SCAN menu starts scanning. Pressing the EXIT key disables scanning. An internal or external scan cannot be temporarily disabled.

Ratio/delta measurements

After ratio or delta measurements are selected from the CONFIG-SCAN menu, the SCAN, TRIG, and EXIT keys control scanning. Press the SCAN key to start the operation, as shown in Figure 3-43.

Manual scanning

When using internal scanning, you can manually scan channels by pressing the ◄ or ► keys. To use this feature, first close a channel by using the CLOSE-CHANNEL option accessible with the CHAN key. Use ► to increment channels, or use ◄ to decrement channels. Hold down either key to continuously scan through channels manually.

Adjacent channel display

The multiple display mode can be used to display the two adjacent channels only when manually controlling channels. To use this feature, first manually close the desired channel, then press PREV to display alternate channels. You can then use the ◄ and ► keys to scroll through channel displays normally.

NOTE

The adjacent channel display mode cannot be used when scanning channels automatically using the internal or external scan list.

As an example, assume that you close channel 5 using the CHAN key. With the multiple display enabled, channels 4 and 6 will appear on the lower display line.

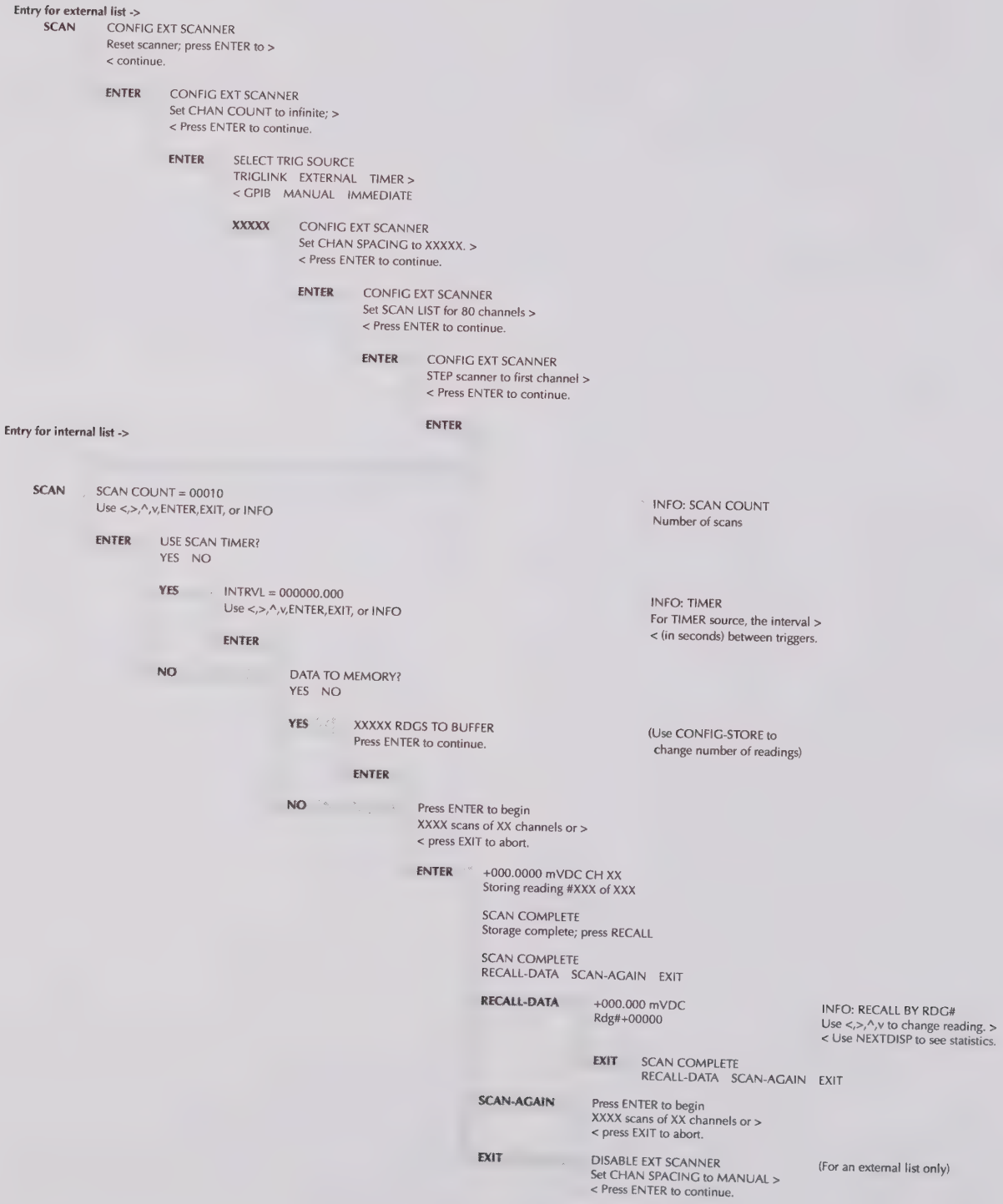


Figure 3-42
SCAN key menu structure

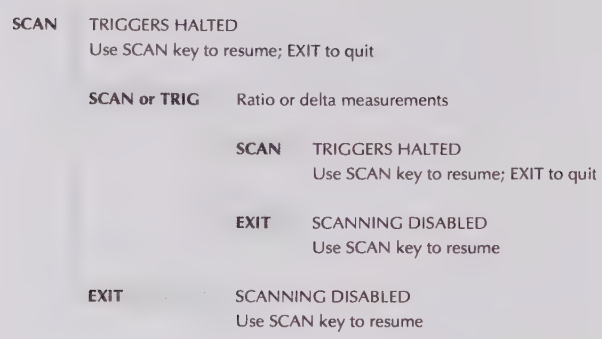


Figure 3-43
SCAN key menu structure for ratio and delta

3.11.8 Scanner operation examples

The following paragraphs give step-by-step procedures for various scanner operating modes.

Closing and opening channels

Use the front panel CHAN key to close and open specific channels on the internal scanner card as follows:

1. From normal display, press the CHAN key. The instrument will display the following menu:

   CHANNEL SELECTION
   CLOSE-CHANNEL OPEN-ALL-CHANNELS

2. Select CLOSE-CHANNEL, then press ENTER. The Model 2001 will display the following prompt:

   ENTER CHANNEL# 01 (1-10)

3. Use the cursor and range keys to select the channel you wish to close (1-10), then press ENTER. Any previously closed channel will open, and the selected channel will close.
4. To open the close channel, select OPEN-ALL-CHANNELS in the CHANNEL SELECTION menu, then press ENTER.

Manual scanning and using the multiple display

The ◄ and ► keys can be used to manually scan through channels on the internal scanner card. The multiple display mode can also be used to display adjacent scanner channels while scanning manually.

NOTE

Adjacent channel display cannot be used when the instrument is scanning automatically.

Follow the steps below to scan manually and display alternate channels.

1. Manually close a channel by using the CLOSE-CHANNEL selection accessible with the CHAN key.
2. Press the ► key to manually increment channels, or press the ◄ key to manually decrement channels. Hold down either key to manually scan through channels continuously. Auto-repeat of cursor keys is disabled when adjacent channel next display is shown.
3. With the unit in the normal display mode, press the PREV key to enable adjacent channel display. Note that the lower and upper adjacent channel readings will appear on the lower display section.
4. Manually scan through channels with the ◄ or ► key. Note that the adjacent display channel numbers track the channel on the main display.
5. Press the NEXT key to cancel the alternate channel display mode, then use the CHAN key to open channels when done scanning.

Scanning internal channels

Internal channels are scanned by configuring scan channels and programming the Model 2001 to perform a scan. The following steps demonstrate the basic procedures for performing basic scanning using the internal scanner card.

NOTE

Depending on selected trigger modes, it may be necessary to trigger the instrument to perform scanning. Refer to paragraph 3.7 for detailed information on triggering.

Step 1: Configure channels

Use CONFIG-CHAN to select the measurement functions for each of the scanner channels as follows:

1. Press CONFIG-CHAN. The instrument will display the following menu:

   CONFIGURE CHANNELS
   INTERNAL-CHANS EXTERNAL-INPUTS ►
   ◄ SAVE-ALT-FCN RESTORE-ALT-FCN

2. Select INTERNAL-CHANS, then press ENTER. The multimeter will display the following menu:

   SET INTERNAL CHANS
   1=DCV 2=DCV 3=DCV 4=DCV 5=DCV ▶
   ◀ 6=DCV 7=DCV 8=DCV 9=DCV 10=DCV

3. Using the cursor keys, select the desired channel (press the right cursor key to display channels 6 through 10).
4. Using the range keys, select the desired measurement function: DCV, ACV, Ω2W, Ω4W, FRQ, TMP, ALT, JN1, JN2, JN3, JN4, JN5, --- (None).
5. Repeat steps 3 and 4 for each of the channels you wish to scan. Note: Select --- (none) to omit a channel from the scan list.
6. Examine all ten channels to verify omitted channels and paired (PRD) channels.
7. After selecting all measurement functions, press ENTER to return to normal display.

Step 2: Select internal scan list

Use CONFIG-SCAN to select the internal scan list as follows:

1. Press CONFIG-SCAN. The Model 2001 will display the following:

   SCAN OPERATION
   INTERNAL EXTERNAL RATIO DELTA

2. Select INTERNAL, then press ENTER.

Step 3: Start scan

After configuring channels and scan list, simply press the SCAN key to begin scanning. The instrument will prompt you to configure the scan count and scan timer, and to enable data storage. Pressing the ENTER key will scan through selected channels and make a measurement on each channel using the previously selected measurement function for each channel. When the scan has completed, you can recall stored data and/or scan again. To disable scanning, press the EXIT key.

Using ratio and delta

The Model 2001 can display the difference (DELTA) or quotient (RATIO) between the signal on any two internal scanner channels. The following paragraphs discuss ratio and delta calculations and also give step-by-step procedures for using ratio and delta.

When the instrument is first placed in the ratio or delta mode, it will close the scanner reference channel and then wait for a trigger. When the reading is triggered, the unit will make a measurement on the reference channel, switch to the measurement channel, and then take a second measurement. After measuring the measurement channel, the unit will compute and display the ratio or delta value, and switch back to the reference channel to wait for the next trigger.

The steps below outline the basic procedure for making ratio measurements. The procedure for delta measurements is essentially the same, except that you would select DELTA in the appropriate menu.

Step 1: Connect inputs

Input signals must be connected to the two channels you intend to define as measurement and reference channels.

Step 2: Define measurement channel

1. From normal display, press CONFIG-SCAN. The instrument will display the following:

   SCAN OPERATION
   INTERNAL EXTERNAL RATIO DELTA

2. Select RATIO, then press ENTER. The Model 2001 will display the following:

   CONFIGURE RATIO
   MEASURE REFERENCE FUNCTION

3. Select MEASURE, then press ENTER. The instrument will display the following:

   RATIO MEASURE CHAN
   CH1 2 3 4 5 6 7 8 9 10

4. Using the cursor keys, select the channel you wish to define as the measure channel, then press ENTER.

Step 3: Define reference channel

1. From the CONFIGURE RATIO menu, select REFERENCE, then press ENTER. The Model 2001 will display the following message:

   RATIO REFERENCE CHAN
   CH1 2 3 4 5 6 7 8 9 10

2. Using the cursor keys, select the channel to be defined as the reference channel, then press ENTER.

Step 4: Select measurement function

1. From the CONFIGURE RATIO menu, select FUNCTION, then press ENTER. The instrument will display the following:

   SET RATIO FUNCTION
   DCV Ω2 Ω4

Note that only DC volts, and 2- and 4-wire ohms functions are available for ratio and delta modes.

2. Use the cursor keys to select the desired function, then press ENTER.
3. Press EXIT as necessary to return to normal display.

Step 5: Display ratio readings

Once the reference channel, measurement channel, and ratio function have been defined, press SCAN to halt triggers, then press TRIG or SCAN to display ratio readings. The instrument will automatically display ratio readings computed from signals applied to the reference and measurement channels. If you have selected a trigger mode that requires a separate trigger for each reading, you will, of course, have to trigger the instrument to obtain each ratio reading (refer to paragraph 3.7 for details on triggering).

Step 6: Disabling and cancelling the ratio mode

You can disable the ratio mode by pressing EXIT while ratio readings are being displayed. To cancel the ratio mode, press CONFIG-SCAN, then select another option under the SCAN-OPERATION menu.

RTD temperature measurements

The following paragraphs outline the basic procedures for making RTD temperature measurements using the internal scanner. For more detailed information on temperature measurements in general, refer to paragraph 3.4.5.

Step 1: Connect RTD probes

Connect RTD probes to the scanner using the basic resistance connections outlined in the scanner card manual. For 4-wire probes, pair the connections as follows:

- Channels 1 and 6: probe #1
- Channels 2 and 7: probe #2
- Channels 3 and 8: probe #3
- Channels 4 and 9: probe #4
- Channels 5 and 10: probe #5

Step 2: Select sensor type and units

Use CONFIG-TEMP to select the RTD sensor type and the units you wish to display. See paragraph 3.4.5 for details.

Step 3: Configure channels

1. Press CONFIG-CHAN. The instrument will display the following:

   CONFIGURE CHANNELS
   INTERNAL-CHANS EXTERNAL-INPUTS ▶
   ◀ SAVE-ALT-FCN RESTORE-ALT-FCN

2. Select INTERNAL-CHANS. The Model 2001 will display the following:

   SET INTERNAL CHANNELS
   1=DCV 2=DCV 3=DCV 4=DCV 5=DCV ▶
   ◀ 6=DCV 7=DCV 8=DCV 9=DCV 10=DCV

3. Use the cursor and range keys to select channels and functions. Set the function type to TMP for all channels connected to RTD probes. Select --- (none) for channels without probes connected.
4. Press ENTER to return to normal display.

Step 4: Configure scan

1. From normal display, press CONFIG-SCAN. The instrument will display the following:

   SCAN OPERATION
   INTERNAL EXTERNAL RATIO DELTA

2. Select INTERNAL, then press ENTER.

Step 5: Scan channels

To start scanning, press the SCAN key and program the scan count, scan timer, and data storage. Then press ENTER. When the scan has completed, you can recall stored data and/or scan again. Press EXIT while scanning to interrupt data storage and disable scanning.

Using the scanner with the data storage buffer

The Model 2001 internal data storage buffer can be used to store readings taken while using the scanner. The following paragraphs outline the basic steps necessary for data storage of scanner readings. Refer to paragraph 3.8 for additional information on using the data storage buffer.

Step 1: Configure channels

1. Press CONFIG-CHAN. The instrument will display the following:

   CONFIGURE CHANNELS
   INTERNAL-CHANS EXTERNAL-INPUTS ▶
   ◀ SAVE-ALT-FCN RESTORE-ALT-FCN

2. Select INTERNAL-CHANS. The Model 2001 will display the following:

   SET INTERNAL CHANNELS
   1=DCV 2=DCV 3=DCV 4=DCV 5=DCV ▶
   ◀ 6=DCV 7=DCV 8=DCV 9=DCV 10=DCV

3. Use the cursor and range keys to select channels and functions, then press ENTER when you have set all functions and channels.

4. Press EXIT to return to normal display.

Step 2: Configure scan

1. From normal display, press CONFIG-SCAN. The instrument will display the following:

   SCAN OPERATION
   INTERNAL EXTERNAL RATIO DELTA

2. Select INTERNAL, then press ENTER.

Step 3: Configure buffer

1. Press CONFIG-STORE. The unit will display the following:

   CONFIG DATA STORE
   BURST-MODE DATA CONTROL ▶
   ◀ CLEAR-ALL COUNT FEED

2. Select COUNT, then press ENTER. The instrument will display the following:

   SET BUFFER SIZE
   ENTER-COUNT USE-TRIGGER-MODEL

3. Select ENTER-COUNT and press ENTER to view the following:

   BUFFER SIZE = 00010

4. Using the cursor and range keys, select the number of readings to store. Usually, this number should be the same of the number of channels you are scanning. For example, if you are using all 10 scanner channels, select 10 readings. Note that channel information is not saved with compact data grouping.
5. Press ENTER to complete programming data storage; then EXIT to return to normal display.

Step 4: Trigger scan

Press SCAN to program the scan count, scan timer, and data storage. Then press ENTER. The unit will cycle through the channels, stopping to take and store a reading on each channel.

Step 5: Recall readings

From the SCAN COMPLETE menu, select the RECALL-DATA option to display readings stored in the buffer. Use the cursor and range keys to select the reading number to display. Note that the instrument will display the channel number for each buffer reading in addition to other pertinent buffer information. Press EXIT to return to the SCAN COMPLETE menu.

External scanning

Follow the general steps below to set Model 2001 modes for external scanning.

Step 1: Make scanner card connections

Be sure to connect your scanner signal lines and trigger cables as appropriate. See the scanner card documentation for details on signal connections. Paragraphs 3.7.6 and 3.7.7 provide information on external triggering and using the trigger link.

Step 2: Configure trigger parameters

Using CONFIG-TRIG, select the required trigger layer parameters based on the desired scanner and multimeter operation. See paragraph 3.7 for Model 2001 trigger parameter details.

Step 3: Configure external channels and functions

1. From normal display, press CONFIG-CHAN. The instrument will display the following:

   CONFIGURE CHANNELS
   INTERNAL-CHANS EXTERNAL-INPUTS ▶
   ◀ SAVE-ALT-FCN RESTORE-ALT-FCN

2. Select EXTERNAL-INPUTS, then press ENTER. The Model 2001 will prompt you to enter the number of channels:

   # EXTERNAL INPUTS=80

3. Use the range and cursor keys to set the number of external channel you will be using, then press ENTER. The instrument will prompt you to set functions:

   SET CHAN FUNCTIONS
   DEFAULT CHOOSE-FUNCTIONS

4. If you wish to use the current default function for all channels, select DEFAULT, then press ENTER.
5. If you intend to program a separate function for each channel, choose CHOOSE-FUNCTIONS, then press ENTER. The instrument will prompt you for a channel number, as in the following typical display:

   SELECT CHAN=01 (DCV)

6. Use the cursor and range keys to select a channel, then press ENTER. Select the desired function, then press ENTER. Repeat the procedure for all channels to be defined.
7. Press EXIT as necessary to return to normal display.

Step 4: Enable external scanning

8. From normal display, press CONFIG-SCAN. The instrument will display the following:

   SCAN OPERATION
   INTERNAL EXTERNAL RATIO DELTA

9. Select EXTERNAL, then press ENTER.

Step 5: Start scan

Press SCAN for instructions to set up the external scanner, program the scan count, scan timer, and data storage. Then press ENTER to start scanning. When the scan has completed you can recall stored data and/or scan again. Press EXIT to interrupt data storage and disable scanning.

3.12 Menu

The main menu accesses the various instrument operations for which there are no dedicated keys, such as setup storage, IEEE-488 setup, calibration, self-test, and limits. The main menu structure is summarized in Table 3-42.

The top level of the main menu is displayed by placing the instrument in the reading display state, and then pressing the MENU key. The main menu options are shown as follows:

MAIN MENU
SAVESETUP GPIB CALIBRATION ▶
◀ TEST LIMITS STATUS-MSG GENERAL

Some general rules to navigate the menu levels are given in paragraph 3.3.

Table 3-42
Main menu structure

Menu item	Description
SAVESETUP SAVE RESTORE POWERON BENCH GPIB USER-SETUP-NUMBER RESET BENCH GPIB	Setup menu: Save setup at a memory location (up to 1, 5, or 10). Return 2001 to setup stored at a memory location (up to 1, 5, or 10). Power-on Menu: Power on to bench default setup conditions. Power on to GPIB default setup conditions. Power on to setup stored at a memory location (up to 1, 5, or 10). Reset Menu: Return 2001 to bench default setup. Return 2001 to GPIB default setup.
GPIB ADDRESSABLE TALK-ONLY FEED AFTER-CALC BEFORE-CALC NONE INTERFACE IEEE-488 CENTRONICS INTERVAL FORMFEED CONTROL SET-PAGE-SETUP ELEMENTS STATUS	GPIB/Printer Setup menu: Check/change IEEE-488 bus address (0-30). GPIB/Printer Talk-only mode menu: GPIB Output Feed menu: Specify reading after math operation. Specify reading before math operation. Specify no readings. Select printer interface. Specify IEEE-488 printer. Specify Centronics parallel printer. Specify printing interval (every reading to 1 out of 9999). Formfeeds menu: Enable/disable page breaks. Set number line between form feeds (1-255). Select GPIB data elements (reading, units, reading number, channel number, timestamp, status). Display IEEE-488 bus status byte.
CALIBRATION COMPREHENSIVE AC-ONLY-CAL CALIBRATION-DATES	Calibration menu: Perform DC and AC calibration. Perform AC calibration only (open-circuit). Check/change calibration date.
TEST BUILT-IN-TEST AUTOMATIC MANUAL DIAGNOSTICS FRONT-PANEL-TESTS KEYS DISPLAY-PATTERNS	Self-test menu: Test analog and digital boards. Run all tests automatically. Select tests to run. Factory diagnostic tests. Test display board. Verify operation of front panel keys. Verify operation of display.

Table 3-42 (cont.)
Main menu structure

Menu item	Description
LIMITS	Limits menu:
LIMIT-SET-1	Limit-Set-1 menu:
CONTROL	Enable/disable limit set #1.
LOLIM1	Set value of low limit #1.
HILIM1	Set value of high limit #1.
LIMIT-SET-2	Limit-Set-2 menu:
CONTROL	Enable/disable limit set #2.
LOLIM2	Set value of low limit #2.
HILIM2	Set value of high limit #2.
STROBE-CONTROL	Enable/disable limit strobe signal of digital output #4 when trigger occurs.
PASS-PATTERN	Specify patterns on digital outputs to signify limits pass.
STATUS-MSG	Enable/disable status message mode.
GENERAL	General menu:
DIGITAL-I/O	Digital I/O menu:
OUTPUT-STATE	Check/change states of digital output lines.
OUTPUT-SENSE	Check/change sense of digital output lines.
INPUT	Read digital input line.
SERIAL#	Display serial number, memory option SCPI version, and firmware revisions.
AUTOZERO	Disable or enable normal (after every reading) or synchronous (every 200ms) autozero mode.
LINE-SYNC	Enable/disable line synchronization of measurements.
DECIMAL	Select period or comma for display of decimal point.

3.12.1 SAVESETUP

The SAVESETUP option of the main menu is used for the following operations:

- To save the present instrument configuration in non-volatile memory.
- To restore the instrument to a previously saved instrument configuration.
- To set the instrument's power-on configuration.
- To reset the instrument to a factory default configuration.

To display the SAVESETUP menu from the top level of the main menu, use the cursor keys (◄ and ►) to place the cursor on SAVESETUP, then press ENTER. The following is displayed:

SETUP MENU
SAVE RESTORE POWERON RESET

SAVE

Use this menu item to save the present instrument setup in a specific memory location. Depending on the memory option, you can store up to one (STD), five (MEM1), or ten (MEM2) setups in non-volatile memory. The installed memory option is displayed on power-up, and in the SERIAL# option of the General Menu (see paragraph 3.12.7).

1. To select SAVE, place the cursor on it and press ENTER. The following message is displayed for a Model 2001/MEM1:

   SAVE SETUP #0 (4 max)

   Note that the numbering of the setup locations starts with SETUP#0.

2. To save the present instrument setup in the displayed memory location, press ENTER. After displaying the message "Saving Setup n", the instrument returns to the SETUP MENU.
3. To save the present setup in a different memory location (for those units with optional memory), use the RANGE ▲ and ▼ keys to increment and decrement the location number, then press ENTER. The instrument returns to the SETUP MENU.

RESTORE

Use this menu item to return the instrument to a setup that was previously stored in memory. Depending on the memory option, up to one (STD), five (MEM1), or ten (MEM2) setups can be saved in non-volatile memory.

1. To select RESTORE, place the cursor on it and press ENTER. The following message is displayed for a Model 2001/MEM1:

   RESTORE #0 (4 max)

   Note that the numbering of the setup locations starts with SETUP#0.
2. To restore the instrument setup saved at the displayed memory location, press ENTER. The instrument returns to the normal display of readings.
3. To restore a different setup (for those units with optional memory), use the RANGE ▲ and ▼ keys to increment and decrement the location number, then press ENTER. The instrument returns to the normal display of readings.

POWERON

Use this menu item to select the instrument setup that goes into effect on power-on.

The instrument can be set to power on to the factory bench defaults, the factory GPIB defaults, or to a user setup stored at a specific memory location.

To select the POWERON menu item, place the cursor on POWERON and press ENTER. The following menu is displayed:

SET POWER-ON DEFAULT
BENCH GPIB USER-SETUP-NUMBER

BENCH: With this option, the instrument returns to the bench default conditions (see Table 3-43) the next time it is turned on. To select the bench defaults, place the cursor on BENCH and press ENTER. The instrument returns to the SETUP MENU.

GPIB: With this option, the unit returns to the GPIB default conditions (see Table 3-43) the next time it is turned on. To select the GPIB defaults, move the cursor to GPIB and press ENTER. The instrument returns to the SETUP MENU.

USER-SETUP-NUMBER: Using this option, the instrument powers on to a user setup saved at a specific memory location. To select a user setup, place the cursor on USER-SETUP-NUMBER and press ENTER. The following message is displayed for the Model 2001/MEM1:

PWRON DFLT#0 (4 max)

1. To power on to the setup stored at the displayed memory location, press ENTER. The instrument returns to the SETUP MENU.
2. To power on to setup stored at a different memory location (for those units with optional memory), use the RANGE ▲ and ▼ keys to increment and decrement the location number, then press ENTER.

RESET

Use this menu option to reset the instrument to the bench or GPIB default conditions (see Table 3-43).

To select RESET, place the cursor on RESET and press ENTER. The following menu is displayed:

RESET ORIGINAL DFLTS
BENCH GPIB

BENCH: With this option, the instrument returns to the bench default conditions (see Table 3-43). To select the option, place the cursor on BENCH and press ENTER. The instrument returns to the normal display of readings after requesting an ENTER to confirm your selection.

GPIB: With this option, the unit returns to the GPIB default conditions (see Table 3-43). To select the option, move the cursor to GPIB and press ENTER. The instrument returns to the normal display of readings after requesting an ENTER to confirm your selection. Note that the instrument goes to the Idle state.

Table 3-43
Factory default conditions

Function or operation	Bench default	GPIB default
AC current:		
AC-type	RMS	RMS
Coupling	AC	AC
Filter	Off	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	5%	5%
Filter mode	Moving	Repeat
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (5.5d)	Auto (5.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
AC voltage:		
AC-type	RMS	RMS
Peak spikes window	0.1sec	0.1sec
Coupling	AC	AC
Filter	Off	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	5%	5%
Filter mode	Moving	Repeat
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (5.5d)	Auto (5.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
Units	Volts	Volts
dB reference	1V	1V
dBm reference	75Ω	75Ω
Autozero	On (Normal)	On (Normal)
Buffer:		
Burst mode	No effect	No effect
Control	No effect	No effect
Count	No effect	No effect
Data group	No effect	No effect
Feed	No effect	No effect

Table 3-43 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
DC current:		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Measurement mode	Normal	Normal
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
DC voltage:		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
Digital I/O:		
Output states	No effect	No effect
Output sense	No effect	No effect
Frequency:		
Coupling	AC	AC
Maximum signal level:		
Function	Voltage	Voltage
Voltage level	10V	10V
Current level	1mA	1mA
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (5d)	Auto (5d)
Terminals	Voltage	Voltage
Trigger level	0.0	0.0
Function	DCV	DCV

Table 3-43 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
Limits:		
Limit set #1	Off	Off
Low limit #1	-1.0	-1.0
Low limit #1 action	0	0
High limit #1	1.0	1.0
High limit #1 action	0	0
Limit set #2	Off	Off
Low limit #2	-1.0	-1.0
Low limit #2 action	0	0
High limit #2	1.0	1.0
High limit #2 action	0	0
Strobe control	Off	Off
Pass pattern	0	0
Line synchronization	Off	Off
Math	Off	Off
Function	Percent	Percent
Reference for percent	1.0	1.0
Scale factor for mX+b	1.0	1.0
Offset for mX+b	0.0	0.0
Resistance (2-wire):		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Offset compensation	Off	Off
Range	Auto	Auto
Maximum autorange	1GΩ	1GΩ
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)

Table 3-43 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
Resistance (4-wire):		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Offset compensation	Off	Off
Range	Auto	Auto
Maximum autorange	200kΩ	200kΩ
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
Scanning:		
Channels	No effect	No effect
Scan list:		
Internal list	No channels	No channels
External list	No channels	No channels
Function	DC voltage	DC voltage
Scan operation	None	None
Ratio:		
Reference channel	5	5
Measure channel	10	10
Function	DC voltage	DC voltage
Delta:		
Reference channel	5	5
Measure channel	10	10
Function	DC voltage	DC voltage

Table 3-43 (cont.)
Factory default conditions

Function or operation	Bench default	GPIB default
Temperature:		
Filter	On	Off
Auto	On	Off
Averaging	On	On
Readings	10	10
Filter mode	Moving	Repeat
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (0.01°C)	Auto (0.01°C)
RTDs:		
Type	PT385	PT385
Resistance at 0°C	100Ω	100Ω
Alpha	0.00385	0.00385
Beta	0.111	0.111
Delta	1.507	1.507
Sensor	4-wire RTD	4-wire RTD
Speed	Normal (1 PLC)	Normal (1 PLC)
Thermocouples:		
Type	J	J
Reference junction	Simulated	Simulated
Default temperature	23°C	23°C
Real junction temp. coefficient	10mV/°C	10mV/°C
Offset	0mV @ 0°C	0mV @ 0°C
Units	°C	°C
Triggers:	Armed	Idled
arm layer:		
Source	Immediate	Immediate
Triglink input	Line 2	Line 2
Triglink output	Line 1	Line 1
Count	1	1
Control	Acceptor	Acceptor
scan layer:		
Source	Immediate	Immediate
Triglink input	Line 2	Line 2
Triglink output	Line 1	Line 1
Delay	0	0
Count	Infinite	1
Control	Acceptor	Acceptor
measure layer:		
Source	Immediate	Immediate
Triglink mode	Asynchronous	Asynchronous
Triglink input	Line 2	Line 2
Triglink output	Line 1	Line 1
Timer	0.1sec	0.1sec
Delay	0	0
Count	Infinite	1
Control	Acceptor	Acceptor

3.12.2 GPIB

The GPIB menu is used for the following operations:

- To view or change the IEEE-488 address.
- To select the talk-only mode and its parameters.
- To select the data elements to send.
- To view the status byte of the instrument.

To display the GPIB menu from the top level of the main menu, use the cursor keys (◄ and ►) to place the cursor on GPIB, then press ENTER. The following is displayed:

```
GPIB/PRINTER SETUP
ADDRESSABLE  TALK-ONLY ►
◄ ELEMENTS  STATUS
```

Changing between "Addressable" and "Talk-only" causes triggers to be halted.

ADDRESSABLE

With the instrument set for "Addressable", it can listen and talk to a bus controller. This menu item lets you check and/or change the IEEE-488 address of the instrument.

At the factory the address is set to 16, but it can be changed to any value from 0 to 30. To select ADDRESSABLE, place the cursor on it and press ENTER. If the address is presently set to 16, the following message is displayed:

```
ADDRESS = 16 (0-30)
```

1. To retain the displayed address, press ENTER or EXIT. The instrument returns to the GPIB/PRINTER SETUP menu.
2. To change the address, use the RANGE ▲ and ▼ keys to increment and decrement the number, then press ENTER. The instrument returns to the GPIB/PRINTER SETUP menu.

TALK-ONLY

In the talk-only mode, the Model 2001 ignores commands from the bus and merely outputs data, as requested by the printer. When the instrument is in the talk-only mode, the TALK annunciator turns on.

To select the talk-only mode, place the cursor on TALK-ONLY and press ENTER. The following menu is displayed:

```
GPIB/PNTR TALK-ONLY
FEED  INTERFACE  INTERVAL  FORMFEED
```

FEED: This item has options that select the type of readings printed: readings after a math operation is performed (AFTER-MATH), readings before a math operation (BEFORE-MATH), or no readings.

INTERFACE: With the IEEE-488 option of this item, data elements are sent to an IEEE-488 bus printer set for listen always. With the CENTRONICS option, data elements are sent to a printer with a Centronics (parallel) interface. The printer must be connected with a Model 8530 IEEE-488 to Centronics Printer Adapter Cable.

INTERVAL: The INTERVAL option controls how often readings are printed (expressed as 1 out of nnnn readings).

FORMFEED: Use the FORMFEED option of the menu to enable or disable the sending of a formfeed character to the printer after printing a user-selectable number of lines per page (1-255 lines).

ELEMENTS

This menu item lets you select the data elements sent:

- Reading — The numeric value of the reading.
- Units — The units of the reading.
- Reading# — The buffer location of the reading.
- Chan# — The channel number the reading was taken on.
- Time-stamp — The elapsed time from the first buffered reading.
- Status — The reading status information (normal reading, measurement overflow, relative reading).

To select the ELEMENTS menu item, place the cursor on ELEMENTS and press ENTER. The following menu is displayed:

```
GPIB DATA ELEMENTS
READING=y  UNITS=y  READING#=y ►
◄ CHAN#=y  TIMESTAMP=y  STATUS=y
```

where a "y" designates "yes", which is sent, and an "n" designates "no", which is not sent. To retain the displayed selections, press ENTER or EXIT. The instrument returns to the GPIB/PRINTER SETUP menu.

To change a selection, use the ◄ and ► keys to move the cursor, then the RANGE ▲ and ▼ keys to select between "y" and "n". Press ENTER to retain your changes or EXIT to ignore them. In either case, the display returns to the GPIB/PRINTER SETUP menu.

STATUS

Use this menu item to view the IEEE-488 status byte. Refer to Section 4 (IEEE- 488 Reference) for information on the status byte. To select STATUS, place the cursor on STATUS and press ENTER. If, for example, all bits of the status byte are cleared, it is displayed as follows:

SHOW STATUS BYTE
MSB=0 EAV=0 QSB=0 MAV=0 ▶
◀ ESB=0 MSS=0 OSB=0

When finished viewing the status byte, press either ENTER or EXIT. The instrument returns to the GPIB/PRINTER SETUP menu.

The bits in the status byte are refreshed by exiting and re-entering its menu.

3.12.3 CALIBRATION

The CALIBRATION menu is used for the following operations:

- To perform comprehensive calibration.
- To perform AC self-calibration.
- To view or change the calibration date.

Some of the menu items are locked to prevent unintended changing of calibration constants. To display the CALIBRATION menu from the top level of the main menu, use the cursor keys (◀ and ▶) to place the cursor on CALIBRATION, then press ENTER. The following is displayed:

PERFORM CALIBRATION
COMPREHENSIVE AC-ONLY-CAL ▶
◀ CALIBRATION-DATES

COMPREHENSIVE

The procedure for comprehensive calibration is locked; to enable it requires the CAL switch to be pressed. The procedure uses accurate calibration equipment to supply precise DC voltages and resistance values. Refer to the Model 2001 Calibration Manual for instructions.

AC-ONLY-CAL

Use this menu item to perform the AC self-calibration procedure. This procedure requires no external equipment and can be performed at any time by the user to ensure the accuracy of ACV and ACI measurements.

NOTE

The AC calibration constants generated by this procedure are not permanently stored. They are in effect only until the power is turned off. To permanently store AC calibration constants, refer to the Model 2001 Calibration Manual.

To perform an AC-only calibration, follow these steps:

1. The Model 2001 must be allowed to warm up for at least one hour before calibration.
2. Disconnect all test leads or cables from the front and rear INPUT and SENSE jacks.
3. To select AC-ONLY-CAL from the PERFORM CALIBRATION menu, place the cursor on AC-ONLY-CAL and press ENTER. The following message is displayed:

   AC CALIBRATION PHASE
   Open-circuit inputs; Press ENTER ▶
   ◀ to calibrate, or EXIT to abort

4. Press ENTER to begin AC calibration, which takes about six minutes to complete. During AC calibration, the instrument displays the following:

   Calibrating AC: Please wait

   NOTE

   All keypresses are locked out while a calibration step is in progress.

5. Once the process has successfully completed, the message below is displayed, and you can press ENTER or EXIT to return to a normal display:

   AC CAL COMPLETE
   Press ENTER or EXIT to continue.

CALIBRATION-DATES

Use this menu item to view or change the calibration dates. To select CALIBRATION-DATES, place the cursor on CALIBRATION-DATES and press ENTER. The following menu is displayed:

CALIBRATION DATES
VIEW DISPLAY-AT-POWERUP CHANGE

Use the VIEW option of the menu to display the last calibration date and the next calibration date. The DISPLAY-AT-POWERUP option controls whether the next calibration date is displayed during the power-up sequence.

The CHANGE option is locked, to enable it requires the CAL switch to be pressed. The option allows you to change the calibration date and next calibration date. Refer to the Model 2001 Calibration Manual for instructions.

3.12.4 TEST

The SELF-TEST MENU is used as a diagnostic tool to isolate problems with the Model 2001. Information on using these test procedures is included in the optional Model 2001 Repair Manual.

3.12.5 LIMITS

The LIMITS menu is used for the following operations:

- To set and control the limit values that determine the PASS/FAIL and HI/LO status of subsequent measurements.
- To set the digital output patterns that signify passing or failing limit checks.
- To enable/disable a binning strobe signal on digital output #4 for triggering a user-supplied device handler.

NOTE

Since the logic sense of the digital output lines is programmable (high-true or low-true), this discussion of limits uses the logical terms TRUE/FALSE and ON/OFF, rather than HIGH and LOW.

There are two sets of limits, each with high and low limit values. You can program and enable one or both limit sets. With both sets enabled, the values can overlap or one set can be included in the other. The only restriction is that, within the same set, the high limit must be greater than the low limit for a valid test.

The limit test is performed after mX+b and percent math operations. Unit prefixes are applied before the limit test, for example:

- Low limit = -1.0, High limit = 1.0.

  A 150mV reading equals 0.15V (PASS).
- Low limit = -1.0, High limit = 1.0.

  A 0.6kΩ reading equals 600Ω (FAIL).

Limit set #1 is available as a multiple display, which shows a bar graph and a pass/fail indication for the measurements. (Note: The PASS/FAIL indication is not available for ACV, ACI, and in-circuit current because other information is displayed in its place.) While the limits bar graph is displayed, the programmed values for limit set #1 can be viewed by pressing INFO.

The digital output lines can be programmed to reflect the results of limit tests. The first test that fails sets a programmable digital output pattern, where the test execution order is LOW1, HIGH1, LOW2, HIGH2. If all tests pass, another programmable pattern is set. (Also see DIGITAL I/O in paragraph 3.12.7.)

To display the LIMITS menu from the top level of the main menu, use the cursor keys (◄ and ►) to place the cursor on LIMITS, then press ENTER. The following is shown:

```
LIMITS MENU
LIMIT-SET-1   LIMIT-SET-2 ►
◄ STROBE-CONTROL   PASS-PATTERN
```

LIMIT-SET-1 and LIMIT-SET-2

These menu items are similar in that you can enable or disable either or both limit sets, and program the high and low limit values for either or both limit sets. For example, to select limit set #1, place the cursor on LIMIT-SET-1 and press ENTER. The following menu is displayed:

```
LIMIT SET #1 MENU
CONTROL   LOLIM1   HILIM1
```

CONTROL: This item enables or disables control of the digital output lines by the results of either or both limit set tests. For example, to let limit set #1 control the digital output lines, highlight the CONTROL item in the previous menu and press ENTER. Then highlight the ENABLE item in the next menu and press ENTER. The instrument returns to the LIMIT SET #1 MENU.

LOLIM1, HILIM1, LOLIM2, HILIM2: These items allow you to set values for the low and high limits, and the action performed on the digital output lines for each limit test failure.

To set a high or low limit value, place the cursor on the desired selection and press ENTER. For example, the LOLIM1 selection defaults to the following display:

```
LLIM1=+1.000000e+00
Use ◄ ,► , ▲, ▼, ENTER,EXIT, or INFO
```

Use the ◄ and ► keys and the RANGE ▲ and ▼ keys to move the cursor and increment and decrement the digits. Note that you must enter values in scientific notation. The

ENTER key selects your value and takes you to the next menu level:

```
LLIM #1 ACTION
DIGOUT1=OFF  2=OFF  3=OFF  4=OFF
```

With this menu, you select the action taken if low limit #1 is the first limit to be exceeded. The desired states of the digital outputs can be toggled between ON and OFF with the RANGE ▲ and ▼ keys.

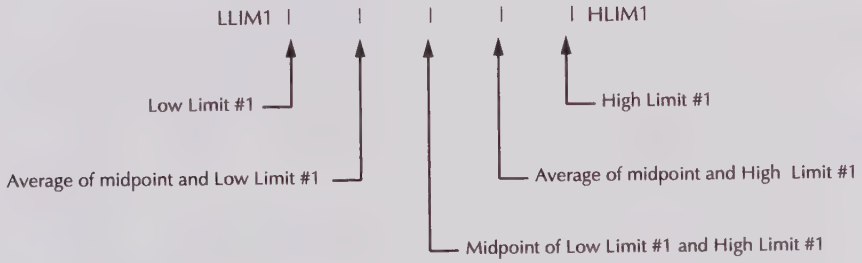
Pressing ENTER returns you to the LIMIT SET #1 menu. Then set the value of the high limit #1 and its effect on the digital outputs. Continue for limit set #2, if desired.

Each measurement function except frequency has a multiple display for the limits bar graph. It shows a pass/fail indication and a graphical representation of the reading compared to limit set #1. (Note: PASS/FAIL indication is not available on ACV, ACI, and in-circuit current.) If low limit #1 is less than high limit #1, you will see a display similar to that shown in Figure 3-44.

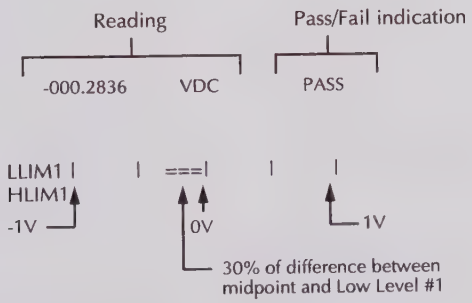
Note that the Model 2001 does not check the validity of the high and low limit values when you enter them. If low limit #1 is greater than or equal to high limit #1, the following message is shown on the bottom line of the limits bar graph next display:

```
No bar graph: LLIM1 >= HLIM1
```

The programmed values for limit set #1 are shown by pressing the INFO key from the limits bar graph next display.


LLIM1
HLIM1
Low Limit #1
High Limit #1
Average of midpoint and Low Limit #1
Average of midpoint and High Limit #1
Midpoint of Low Limit #1 and High Limit #1

A. Defined points of display



NOTES : 1. Press INFO to view the programmed Low Limit #1 and High Limit #1 values.
2. Multiple display of limit values do not use unit prefixes (i.e., volts not millivolts).

B. Example Display with Limits = ±1V

Figure 3-44
Limits bar graph example

STROBE-CONTROL

This menu item enables or disables the use of digital output #4 as a binning strobe signal.

If enabled, the strobe signal is set TRUE for greater than 10 microseconds after all limit tests have been performed on a new reading. The FALSE to TRUE transition can be used to trigger an external device handler to check digital outputs #1-3 for sorting parts into bins.

When binning is enabled from the front panel or with the bus command :CALCulate3:BSTRobe:STATe ON, the binning strobe signal is set to FALSE. When binning is disabled, the strobe signal is left unchanged.

To enable or disable strobe control, place the cursor on STROBE-CONTROL and press ENTER. The following menu is displayed:

```
LIMIT STROBE CONTROL
DISABLED  ENABLED
```

Use the ◄ and ► keys to move the cursor to the desired state, then press ENTER to select it and return you to the LIMITS MENU.

PASS-PATTERN

This item allows you to program the on/off states of the digital output lines for when all limit tests pass. Note that when the binning strobe is enabled, digital output line #4 cannot be used.

To set a pass pattern, place the cursor on PASS-PATTERN and press ENTER. The following menu is displayed:

```
PASS PATTERN
DIGOUT1=OFF  2=OFF  3=OFF  4=OFF
```

Use the ◄ and ► keys and the RANGE ▲ and ▼ keys to move the cursor and toggle the parameter values between OFF and ON. Pressing ENTER returns you to the LIMITS MENU.

Limits example

This example sorts a quantity of 100Ω resistors into five bins, according to the following tolerances:

- Values less than 90Ω (outside -10% tolerance).
- Values greater than 110Ω (outside +10% tolerance).
- Values between 90Ω and 99Ω (meets -10% tolerance).
- Values between 101Ω and 110Ω (meets +10% tolerance).
- Values between 99Ω and 101Ω (meets ±1% tolerance).

The desired test is shown in Figure 3-45. Use the following procedure to program the limits:

1. From the LIMITS menu, set the limit values and actions according to the following table:

Table 3-44
Limit values and actions

Limit	Value	Action
LOLIM1	90Ω	DIGOUT1=ON, others OFF
HILIM1	110Ω	DIGOUT2=ON, others OFF
LOLIM2	99Ω	DIGOUT1=ON, DIGOUT2=ON, others OFF
HILIM2	101Ω	DIGOUT3=ON, others OFF

2. Enable the binning strobe signal from the STROBE-CONTROL item of the LIMITS menu.
3. Set a pass pattern of all lines off from the PASS PATTERN item of the LIMITS menu.
4. Enable the control of the digital output lines by limit set #1 and limit set #2 from the LIMIT SET #1 and LIMIT SET #2 menus. This sets the digital output lines to the "pass pattern" (all OFF in this example). Since binning is enabled, digital output #4 is also OFF.

Note that the actual state (high or low) of the digital output lines depends on the polarity (ACTIVE-HIGH or ACTIVE-LOW). This is programmed from the DIGITAL I/O selection of the GENERAL menu.

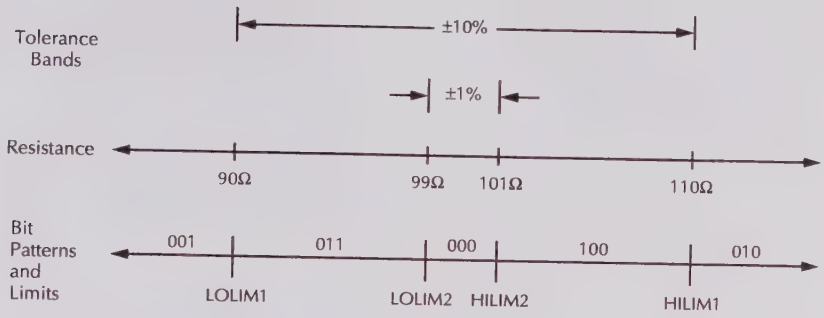


Figure 3-45
Using limit test to sort 100Ω resistors

3.12.6 STATUS-MSG

This selection is used to enable or disable the status messages mode. When enabled, status messages are displayed to identify specific operations that are performed. Place the cursor on STATUS-MSG and press ENTER. The following message is displayed momentarily:

Press EXIT key
to stop status message display.

Then the status message enable/disable menu is shown:

STATUS MESSAGES
OFF ON

Place the cursor on the desired state (OFF or ON) and press ENTER. The instrument returns to the MAIN MENU.

The instrument may become so busy displaying status messages, that keypresses are no longer acknowledged. You may have to clear status message display by pressing the EXIT key or sending a bus command (:DISPlay:SMESsage OFF) to get out of this mode.

3.12.7 GENERAL

The GENERAL menu is used for the following operations:

- To control the state and sense of the digital outputs; to view the state of the digital input.
- To view the serial number, memory option, SCPI version, and firmware revision levels of the Model 2001.
- To control the frequency of autozero readings.
- To set line synchronization of readings.
- To choose the character displayed for a decimal.

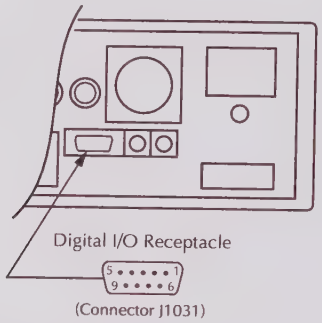
To display the GENERAL menu from the top level of the main menu, use the cursor keys (◄ and ►) to place the cursor on GENERAL, then press ENTER. The following menu is displayed:

GENERAL MENU
DIGITAL I/O SERIAL# AUTOZERO ►
◄ LINE-SYNC DECIMAL

DIGITAL I/O

Overview

The Model 2001's Digital I/O port is a 9-pin "D" sub-miniature connector located on the rear panel. The port's location and pin designations are shown in Figure 3-46.



Pin Designations

1 = Digital Input
2 = N/C
3 = N/C
4 = V_{ext} flyback connection (+5V to +30V)
5 = Digital Ground
6 = Digital Output #1
7 = Digital Output #2
8 = Digital Output #4
9 = Digital Output #3

Figure 3-46
Digital I/O port

The Model 2001's Digital I/O port can be used to control external circuitry. The port provides four output lines and one input line. Each open-collector output can be set high (+5V) or low (0V) and will sink up to 100mA. A TTL high on the Model 2001's digital input is read as "ON". The four output lines can also operate external supplies from +5V to +30V.

Use the DIGITAL I/O menu to select the following options:

- OUTPUT-STATE

  ON or OFF selectable for each output line (1 through 4). Use to check or change the output state.

- OUTPUT-SENSE

  ACTIVE-HIGH or ACTIVE-LOW selectable for each output line (TTL1 through TTL4). Use to check or change the output sense.

- INPUT

  ON or OFF. Use to check or change the status of the digital input line. Sense is fixed at active-high (ON=5V).

Controlling digital circuitry

Each of the four digital, open-collector outputs (connector J1031, pins 6 through 9) includes a built-in pull up resistor to +5V. The output transistor is capable of sinking up to 100mA from voltages up to +30V. The outputs can be controlled independently or tied to one of four limit values (two high, two low). Paragraph 3.12.5 contains information on controlling digital outputs from the limits menu.

Early versions of the Model 2001 have an additional 10kΩ resistor connected between the collector and the internal built-in test circuitry. Under certain combinations of output states, this resistor limits the output high to 2.5V. For example:

Output #1 set high (+5V)
Outputs #2, #3, and #4 set low (0V)
Output #1 is restricted to +2.5V

If using the digital output to sink current from external devices (see external voltage supply later in this paragraph), a Model 2001 containing the additional 10kΩ resistor will function correctly. The transistor switch is open, restricting current flow through the external device in the high state (+5V). However, if the output is directly used as an input to a typical logic input, the 2.5V high state may not be reliably detected as a high. To correct this condition (if a 2.5V high is unacceptable), add external 1kΩ pull-up resistors to the logic circuit inputs, remove the built-in test resistors (R734, R737, R739, and R741), or use an external voltage supply.

External voltage supply

Each output can be operated from external voltage supplies (voltage range from +5V to +30V applied through the device being driven). Refer to Figure 3-47 for a simplified schematic of the digital I/O port. The high current sink capacity of the output driver allows direct control of relays, solenoids, and lamps (no additional circuitry needed). Each output channel contains a fly-back diode for protection when switching inductive loads (such as a low power solenoid or relay coils). To use these fly-back diodes, connect the external supply voltage to pin 4 of J1031 (the digital I/O port). Make sure the external supply voltage is between +5V and +30V and current required by the device does not exceed 100mA.

CAUTION

Do not apply more than 100mA maximum current or exceed +30V maximum voltage on pin 4 of J1031 (the digital I/O port). Applying current or voltage exceeding these limits may damage the instrument.

An externally powered relay connected to the digital output port is shown in Figure 3-48. Other externally powered devices can be similarly connected by replacing the relay with the device. When using the Model 2001's collector outputs to turn on externally powered devices, set the corresponding digital output line parameters as follows (through the GENERAL/DIGITAL I/O menus):

OUTPUT-STATE=ON
OUTPUT-SENSE=ACTIVE-LOW

In the low state (0V), the output transistor sinks current through the external device. In the high state, the output transistor is off (transistor switch is open). This interrupts current flow through the external device. Most applications use active-low (ON=0V) OUTPUT-SENSE. Use the OUTPUT-SENSE menu to check or change the sense of the digital output line.

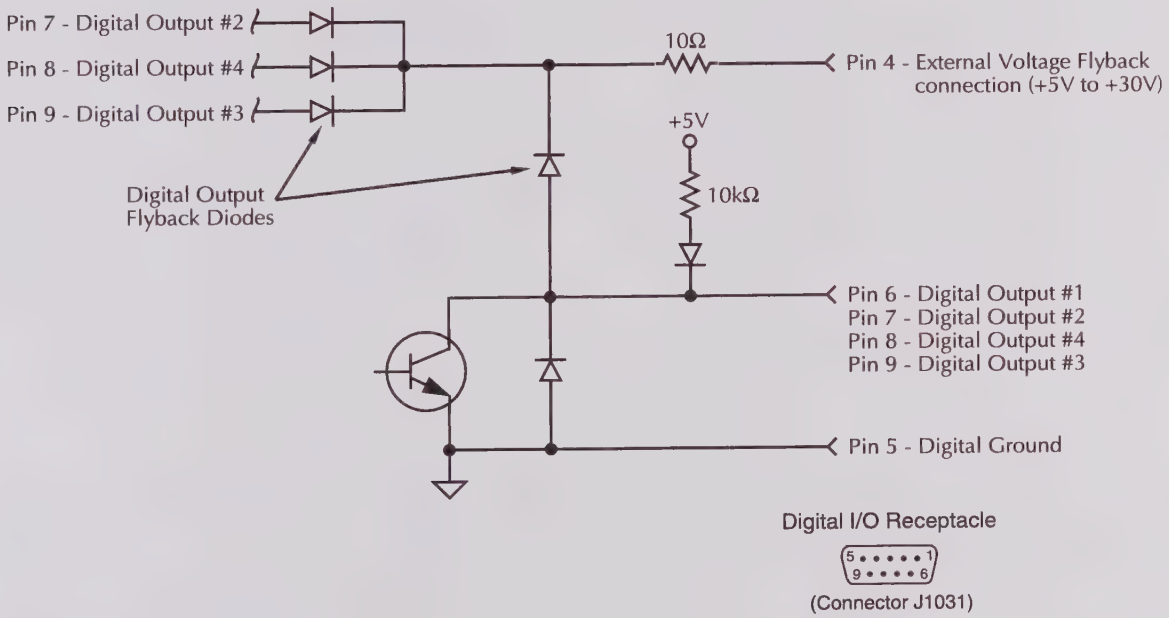

Pin 7 - Digital Output #2
Pin 8 - Digital Output #4
Pin 9 - Digital Output #3
Digital Output
Flyback Diodes
10Ω
Pin 4 - External Voltage Flyback
connection (+5V to +30V)
+5V
10kΩ
Pin 6 - Digital Output #1
Pin 7 - Digital Output #2
Pin 8 - Digital Output #4
Pin 9 - Digital Output #3
Pin 5 - Digital Ground
Digital I/O Receptacle
5 • • • • • 1
9 • • • • • 6
(Connector J1031)

Figure 3-47
Digital I/O port simplified schematic

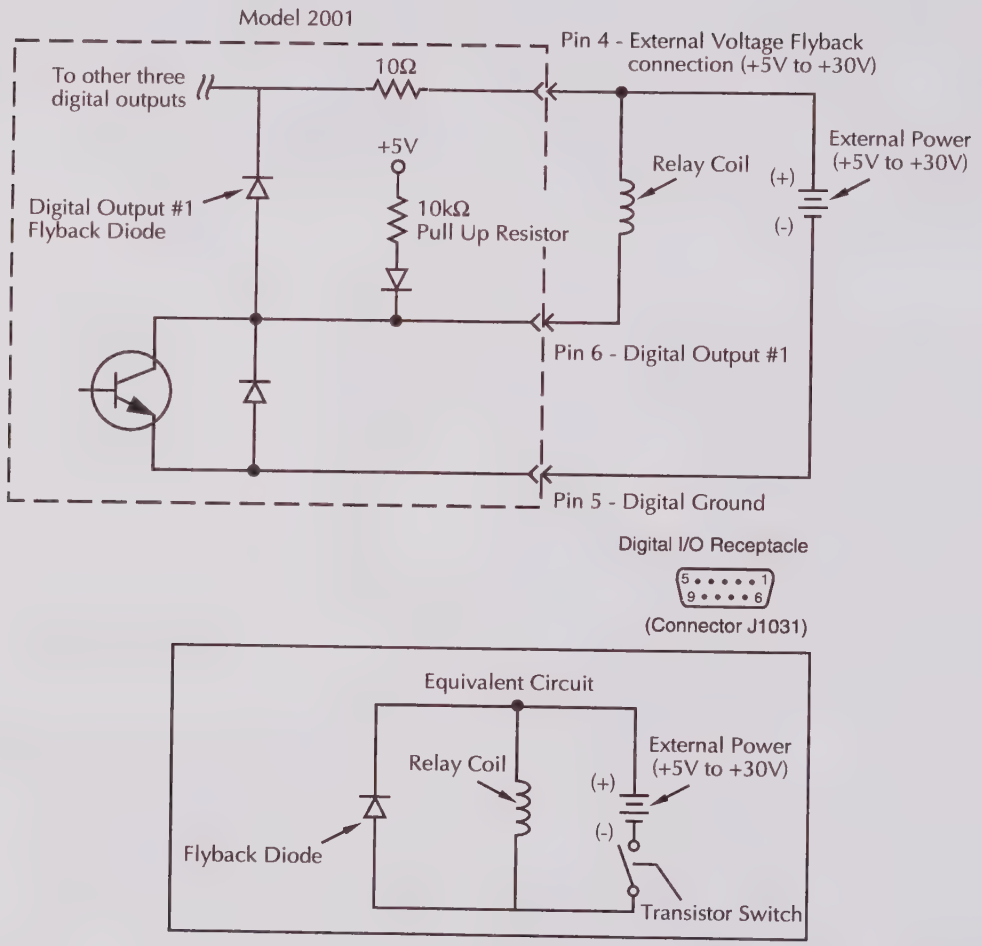


Figure 3-48
Sample externally powered relay

Outputs used as logic inputs

To use the digital outputs as logic inputs to active TTL, Low-power TTL, or CMOS inputs:

1. Connect the Model 2001 digital outputs to the logic inputs.
2. Connect the digital grounds.
3. Using the STATE menu, check the output state setting of the Model 2001 output lines. The STATE value for each output used should be ON.
4. Using the LOGIC-SENSE menu, check the logic-sense setting of the Model 2001 output lines (TTL1 through TTL4). Make sure the correct LOGIC-SENSE value is selected for each output line. The LOGIC-SENSE value varies according to the type of TTL, Low-power TTL, or CMOS inputs used (ACTIVE-HIGH or ACTIVE-LOW).

NOTE

If any LIMITS control is enabled (LOLIM1 or 2, HILIM1 or 2—High, Low, or Pass), the OUTPUT-STATE menu does not check or change the output status. Refer to paragraph 3.12.5 for information about limits.

Input

The single digital input is located on the digital I/O port (connector J1031, pin 1). The input sense is fixed at active-high (ON=5V). Use the INPUT menu to change the status of the input ON or OFF.

Digital I/O menu

Access the DIGITAL I/O menu as follows:

1. Display the GENERAL MENU.
2. Use the ◄ and ► keys to highlight DIGITAL I/O, and press ENTER. The following will be displayed:

   DIGITAL I/O MENU
   OUTPUT-STATE OUTPUT-SENSE INPUT

OUTPUT-STATE: Use this menu item to check or change the state (on or off) of the four digital output lines. The actual level of an "on" line is determined by the sense, which is controlled by the next menu item (OUTPUT-SENSE). To select OUTPUT-STATE, place the cursor on OUTPUT-STATE and press ENTER. If, for example, all the digital output lines are off, the following message is displayed:

DIGITAL OUT LINES
1=OFF 2=OFF 3=OFF 4=OFF

1. To retain the displayed states of the output lines, press ENTER or EXIT. The instrument returns to the DIGITAL I/O MENU.
2. To change the state of one or more digital output lines, perform the following steps:
   A. Position the cursor at the line that you wish to change.
   B. Press the RANGE ▲ or RANGE ▼ key. These keys simply toggle between "ON" and "OFF".
   C. Repeat steps A and B for each line that you wish to change.
   D. With the desired states displayed, press ENTER. The instrument returns to the DIGITAL I/O MENU.

OUTPUT-SENSE: Use this menu item to check or change the sense of the digital output lines. The sense of each line can be active-high (ON = +5V) or active- low (ON = 0V). To select OUTPUT-SENSE, place the cursor on OUTPUT-SENSE and press ENTER. The following message is displayed:

SELECT OUTPUT LINE
TTL1 TTL2 TTL3 TTL4

1. Place the cursor on the appropriate line and press ENTER. A message indicating the sense of the selected line is displayed. For example:

   TTL1 LOGIC SENSE
   ACTIVE-HIGH ACTIVE-LOW

   The cursor position indicates the present sense of the line.
2. To retain the presently selected sense, press ENTER or EXIT. The display returns to the SELECT OUTPUT LINE menu.
3. To change sense, place the cursor on the alternate selection, using the cursor keys (◄ or ►), and press ENTER. The instrument returns to the SELECT OUTPUT LINE menu.
4. When finished, press EXIT to return to the DIGITAL I/O MENU.

INPUT: Use this menu item to read (ON or OFF) the digital input line. Its sense is fixed at active-high (ON = 5V).

To select INPUT, place the cursor on INPUT and press ENTER. If, for example, the digital input line is "ON", the following message is displayed:

DIGITAL INPUT LINE
Status = ON

The status is updated when INPUT is selected; it does not track the status from the previous message. Press ENTER or EXIT to return the instrument to the GENERAL MENU.

SERIAL

To display the serial number, memory option, SCPI version, and firmware revision levels of the instrument, place the cursor on SERIAL# and press ENTER. The following information is displayed:

Serial #XXXXXX MEM1
SCPI version 1991.0 ►
◄ software rev AXX/AYY

where: #XXXXXX is the serial number of the instrument.
MEM1 is the memory option present (also could be STD or MEM2)
AXX is the firmware level for the main microcontroller.
AYY is the firmware level for the display microcontroller.

AUTOZERO

With the AUTOZERO item of the GENERAL MENU, you control the frequency of auto zero readings taken. There are two auto zero modes, normal and synchronous. Either can be selected or the auto zero mode can be completely disabled. Using the Model 2001 with auto zero disabled has two main advantages:

- Increased measurement speed.
- Reduced multiplexer effects on high-impedance measurements.

NOTE

With auto zero disabled, internal calibration and zero are affected by changes in input level. Whenever the applied input signal changes, press the selected function key to perform an auto zero routine; otherwise, substantial measurement errors will result. Zero and calibration may also drift with time; thus, it is recommended that the selected function key be pressed periodically to attain optimum accuracy while auto zero is disabled. An auto zero is also performed whenever the range or function is changed, or when an auto zero bus command is issued.

The correlation between auto zero and measurement speed follows:

- Auto zero off is the fastest.
- Auto zero synchronous is the slowest and most accurate. An auto zero routine is performed for every reading.
- The speed of auto zero normal (default) is between auto zero off and synchronous. An auto zero routine is performed whenever necessary to achieve specified accuracy.

The burst data acquisition mode disables auto zero. This type of measurement requires an auto zero refresh once every 24 hours by performing one of the following:

- Change the display resolution.
- Change the measurement function.

Perform the following steps to display the AUTOZERO menu:

1. Display the GENERAL MENU as described in paragraph 3.12.7.
2. Use the cursor keys (◄ and ►) to highlight AUTOZERO and press ENTER to access the following menu:

   SET AUTOZERO
   DISABLE NORMAL SYNCHRONOUS

The cursor position indicates the present auto zero mode. To retain the presently selected sense, press ENTER or EXIT. The display returns to the SET AUTOZERO menu.

To change sense, place the cursor on the alternate selection, using the cursor keys (◄ or ►) and press ENTER. Any change halts triggers and puts the instrument into the idle state. Use the TRIG key to re-arm triggers. The instrument returns to the SET AUTOZERO menu.

When finished, press EXIT to return to the GENERAL MENU.

LINE-SYNC

Synchronizing A/D conversions with the power line frequency increases common mode and normal mode noise rejection. When line cycle synchronization is enabled, the measurement is initiated at the first positive-going zero-crossing of the power line cycle after the trigger. (See Figure 3-49.)

Perform the following steps to enable or disable power line cycle synchronization of measurements:

1. Display the GENERAL MENU as described in paragraph 3.12.7.
2. Use the cursor keys (◄ and ►) to place the cursor on LINE-SYNC and press ENTER to access the following menu:

   LINE SYNCHRONIZATION
   ENABLED DISABLED

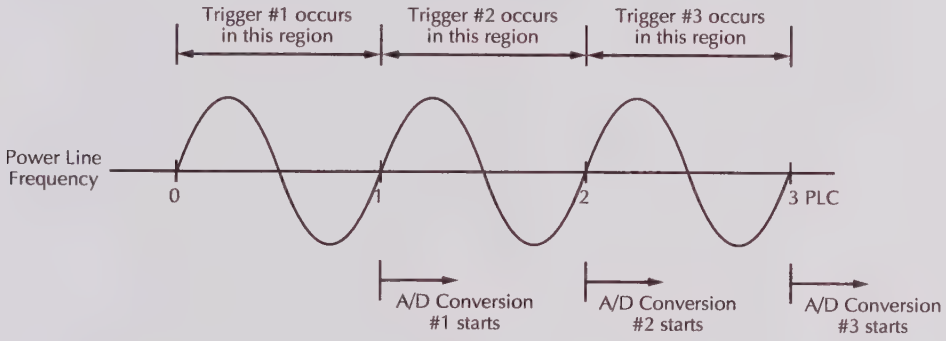
The cursor indicates the present selection. If no change is needed, press EXIT to return to the GENERAL MENU. To change the selection, move the cursor, then press ENTER. Note that this action halts triggers and puts the instrument into the idle state. Use the TRIG key to re-arm triggers.

DECIMAL

This menu item lets you select between periods and commas to signify decimal points on the front panel display. To change the selection from the GENERAL MENU, place the cursor on DECIMAL and press ENTER. The following menu is shown:

CHOOSE DECIMAL CHAR
PERIOD COMMA

Selection of one or the other returns you to the GENERAL MENU. Exit completely from the main menu to view either a period or comma in the normal display of triggered readings.



Note: A/D conversions assume an integration time of ≤ 1 PLC (Power Line Cycle)

Figure 3-49
Line cycle synchronization

4

IEEE-488 Reference

4.1 Introduction

This section contains reference information on programming the Model 2001 over the IEEE-488 bus and is organized as follows:

4.2 **IEEE-488 bus connections:** Explains instrument connections to the IEEE-488 bus.

4.3 **Primary address selection:** Explains how to set the primary address from the front panel.

4.4 **Controller programming:** Summarizes programming statements using HP BASIC 4.0.

4.5 **Front panel aspects of IEEE-488 operation:** Covers status indicators, messages that pertain to bus operation, and the use of the LOCAL key.

4.6 **Status structure:** Explains the various registers and queues that make up the status structure of the Model 2001.

4.7 **Trigger model:** Explains the operation process (Trigger Model) over the IEEE-488 bus.

4.8 **General bus commands:** Covers the general IEEE-488 commands required for basic operations, such as placing the unit in remote.

4.9 **Programming syntax:** Covers the syntax rules for common commands and SCPI commands.

4.10 **Common commands:** Covers the IEEE-488.2 common commands used by the Model 2001.

4.11 **Signal oriented commands:** Covers the command group that can be used to control the measurement process.

4.12–4.24 **SCPI command subsystems:** Covers the SCPI commands used by the Model 2001.

The IEEE-488 is an instrumentation data bus with hardware and programming standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. In 1978 and 1987, the standards were upgraded to IEEE-488-1978 and IEEE-488.1-1987, respectively. The Model 2001 conforms to these standards.

The Model 2001 also conforms to the IEEE-488.2-1987 standard and the SCPI 1991 (Standard Commands for Programmable Instruments) standard. IEEE-488.2 defines a syntax for sending data to and from instruments, how an instrument interprets this data, what registers should exist to record the state of the instrument, and a group of common commands. This subset of commands (common commands) is used to perform basic operations, such as reading status registers, triggering measurements, and resetting the device. The SCPI standard defines a command language protocol. It goes one step farther than IEEE-488.2 and defines a standard set of commands to control every programmable aspect of an instrument. It also defines what format the parameters for those commands should be in and the format for values returned by the instruments.

4.2 IEEE-488 bus connections

The Model 2001 can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example is shown in Figure 4-1. The connector can be stacked to allow a number of parallel connections to one instrument. Two screws are located on each connector to ensure that connections remain secure. Current standards call for metric threads, which are identified with dark colored screws. Earlier versions had different screws, which were silver colored. Do not attempt to use these type of connectors on the instrument, which is designed for metric threads.

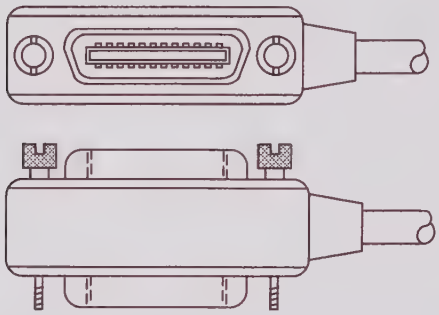


Figure 4-1
IEEE-488 connector

A typical connecting scheme for a multi-unit test system is shown in Figure 4-2. Although any number of connectors could theoretically be stacked on one instrument, it is recommended that you stack no more than three connectors on any one unit to avoid possible mechanical damage.

NOTE

In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. The Models 7007-1 and 7007-2 shielded IEEE-488 cables are available from Keithley.

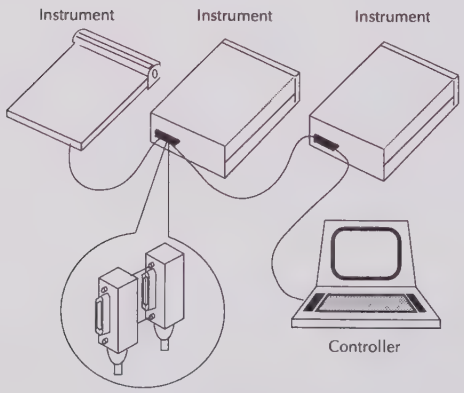


Figure 4-2
IEEE-488 connections

Connect the Model 2001 to the IEEE-488 bus as follows:

1. Line up the cable connector with the connector located on the rear panel. The connector is designed so that it will fit only one way. Figure 4-3 shows the location of the IEEE-488 connector on the instrument.

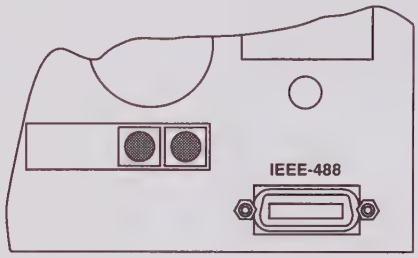


Figure 4-3
IEEE-488 connector location

2. Tighten the screws securely, but do not overtighten them.
3. Add additional connectors from other instruments, as required.
4. Make certain that the other end of the cable is properly connected to the controller. Most controllers are equipped with an IEEE-488 style connector, but a few may require a different type of connecting cable. Consult the instruction manual for your controller for the proper connecting method.

NOTE

The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. The maximum cable length is 20-meters, or two meters times the number of devices, whichever is less. Failure to observe these limits may result in erratic bus operation.

Custom cables may be constructed by using the information in Table 4-1 and Figure 4-4. Table 4-1 lists the contact assignments for the bus, and Figure 4-4 shows the contact configuration.

Table 4-1
IEEE contact designations

Contact number	IEEE-488 designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI (24)*	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN (24)*	Management
18	Gnd, (6)*	Ground
19	Gnd, (7)*	Ground
20	Gnd, (8)*	Ground
21	Gnd, (9)*	Ground
22	Gnd, (10)*	Ground
23	Gnd, (11)*	Ground
24	Gnd, LOGIC	Ground

*Numbers in parentheses refer to signal ground return of referenced contact number. EOI and REN signal lines return on contact 24.

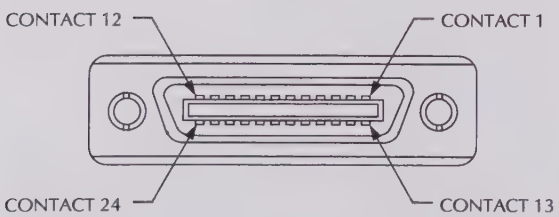


Figure 4-4
Contact assignments

CAUTION

IEEE-488 common is connected to digital common. Maximum voltage between digital common and earth ground is 0V.

4.3 Primary address selection

The Model 2001 must receive a listen command before responding to addressed commands. Similarly, the unit must receive a talk command before transmitting data. The Model 2001 is shipped from the factory with a programmed primary address of 16.

The primary address may be set to any value between 0 and 30 as long as address conflicts with other instruments are avoided. Note that controllers are also given a primary address, so do not use that address either. Most frequently, controller addresses are 0 or 21, but you should consult the controller's instruction manual for details. Whatever primary address you choose, you must make certain that it corresponds with the value specified as part of the controller's programming language.

To check the present primary address or to change to a new one, perform the following procedure:

1. Display the MAIN MENU by pressing the MENU key.
2. Use the cursor keys (◄ and ►) to place the cursor on GPIB and press ENTER. The GPIB/PRINTER SETUP menu will then be displayed.
3. Use the cursor keys to place the cursor on ADDRESSABLE and press ENTER.
4. The current primary address of the instrument will be displayed. For example, if the instrument is set to primary address 16, the following message will be displayed:

   ADDRESS = 16 (0-30)

5. To retain the displayed address, press EXIT three times to return the instrument to the measurement display state.
6. To change the primary address, use the ◄ and ► keys and the ▲ and ▼ keys to display the new address value (0 to 30). The ◄ and ► keys control cursor position and the ▲ and ▼ keys increment and decrement the selected digit.
7. With the desired address value displayed, press ENTER. The address will be stored in non-volatile memory. That is, it will not be lost when the instrument is turned off.
8. Press EXIT two times to return to the measurement display state.

NOTE

Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.

4.4 Controller programming

The programming instructions covered in this section use examples written with Hewlett-Packard BASIC version 4.0. This language was chosen because of its versatility in controlling the IEEE-488 bus. This section covers those statements that are essential to Model 2001 operation.

NOTE

Controller programming information for using the IBM PC interface through the Capital Equipment Corporation (CEC), I/O Tech, and National IEEE-488 interfaces is located in the Appendix.

A partial list of HP BASIC 4.0 statements is shown in Table 4-2. The statements have a one or three digit argument that must be specified. The first digit is the interface select code, which is set to 7 at the factory. The last two digits of those statements requiring a 3-digit argument specify the primary address.

Those statements with a 3-digit argument show a primary address of 16 (the factory set primary address). For a different address, you would, of course, change the last two digits to the required value. For example, to send a GTL command to a device using a primary address of 17, the following statement would be used: LOCAL 717.

Some of the statements have two forms; the exact configuration depends on the command to be sent over the bus. For example, CLEAR 7 sends a DCL command, while CLEAR 716 sends the SDC command to a device with a primary address of 16.

Table 4-2
HP BASIC 4.0 IEEE-488 statements

Action	BASIC statement
Transmit string to device 16.	OUTPUT 716;A$
Obtain string from device 16.	ENTER 716;A$
Send GTL to device 16.	LOCAL 716
Send SDC to device 16.	CLEAR 716
Send DCL to all devices.	CLEAR 7
Send remote enable.	REMOTE 7
Cancel remote enable.	LOCAL 7
Serial poll device 16.	SPOLL (716)
Send local lockout.	LOCAL LOCKOUT 7
Send GET to device 16.	TRIGGER 716
Send IFC.	ABORT 7

4.5 Front panel aspects of IEEE-488 operation

The following paragraphs discuss aspects of the front panel that are part of IEEE-488 operation, including messages, status indicators, and the LOCAL key.

4.5.1 Error and status messages

Table 3-4 summarizes the error and status messages associated with IEEE-488 programming. Note that the instrument may be programmed to generate an SRQ, and command queries can be performed to check for specific error conditions.

4.5.2 IEEE-488 status indicators

The REM (remote), TALK (talk), LSTN (listen), and SRQ (service request) annunciators show the present IEEE-488 status of the instrument. Each of these indicators is briefly described below.

REM — As the name implies, this indicator shows when the instrument is in the remote state. Note that REM does not necessarily indicate the state of the REN line, as the instrument must be addressed to listen with REN true before the REM indicator turns on. When the instrument is in remote, all front panel keys except for the LOCAL key are locked out. When REM is turned off, the instrument is in the local state, and front panel operation is restored.

TALK — This indicator is on when the instrument is in the talker active state. The unit is placed in this state by addressing it to talk with the correct MTA (My Talk Address) command. TALK is off when the unit is in the talker idle state. The instrument is placed in the talker idle state by sending it an UNT (Untalk) command, addressing it to listen, or with the IFC (Interface Clear) command.

LSTN — This indicator is on when the Model 2001 is in the listener active state, which is activated by addressing the instrument to listen with the correct MLA (My Listen Address) command. Listen is off when the unit is in the listener idle state. The unit can be placed in the listener idle state by sending UNL (Unlisten), addressing it to talk, or by sending IFC (Interface Clear) over the bus.

SRQ — The instrument can be programmed to generate a service request (SRQ) when one or more errors or conditions occur. When this indicator is on, a service request has been generated. This indicator will stay on until the serial poll byte is read or all the conditions which caused SRQ have ceased to exist. See paragraph 4.6.8 for details.

4.5.3 LOCAL key

The LOCAL key cancels the remote state and restores local operation of the instrument.

Pressing LOCAL also turns off the REM indicator and returns the display to normal if a user defined message was displayed.

Note that the LOCAL key is also inoperative if the LLO (Local Lockout) command is in effect.

4.6 Status structure

The status register structure of the Model 2001 is shown in Figure 4-5. The following information will explain the various registers and queues that make up this structure.

4.6.1 Standard event status

The reporting of standard events is controlled by two 16-bit registers; the Standard Event Status Register and the Standard Event Status Enable Register. Figure 4-6 shows how these registers are structured.

In general, the occurrence of a standard event sets the appropriate bit in the Standard Event Status Register. This register can be read at any time to determine which, if any, standard events have occurred. Also, with the proper use of the Standard Event Status Enable Register, a standard event can set the Event Summary Bit (ESB) of the Status Byte Register. This allows the programmer to take advantage of the service request (SRQ) feature. See paragraph 4.6.9 for details.

Standard Event Status Register — This is a latched, read only register that is used to record the occurrence of standard events. Each bit in the register (except bit B1 which is not used by the Model 2001) represents a standard event. Descriptions of these standard events are provided in paragraph 4.10.4.

When a standard event occurs, the appropriate bit in the Standard Event Status Register sets. For example, if you attempt to read data from an empty Output Queue, a Query Error (QYE) will occur and set bit B2 of the status register. A set bit in this register will remain set until an appropriate operation is performed to clear the register. The Standard Event Status Register can be read at any time by using the following common query command (see paragraph 4.10.4 for details):

```
*ESR?
```

Reading this register using the *ESR? command also clears the register. The following list summarizes all operations that clear the Standard Event Status Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the *ESR? common command.

Standard Event Status Enable Register — This register is programmed by the user and serves as a mask for standard events. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status Byte Register. Conversely, when a standard event is unmasked, the occurrence of that event will set the ESB bit.

A bit in the Standard Event Status Register is masked when the corresponding bit in the Standard Event Status Enable Register is cleared (0). When the masked bit of the Standard Event Status Register sets, it is ANDed with the corresponding cleared bit in the Standard Event Status Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the ESB bit in the Status Byte Register.

A bit in the Standard Event Status Register is unmasked when the corresponding bit in the Standard Event Status Enable Register is set (1). When the unmasked bit of the Standard Event Status Register sets, it is ANDed with the corresponding set bit in the Standard Event Status Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, sets the ESB bit in the Status Byte Register.

The individual bits of the Standard Event Status Enable Register can be set or cleared by using the following common command (see paragraph 4.10.2 for details):

```
*ESE  <NRf>
```

The Standard Event Status Enable register can be read at any time by using the following common query command (see paragraph 4.10.3 for details):

```
*ESE?
```

Reading this register using the *ESE? command does not clear the register. The following list summarizes all operations that will clear the Standard Event Status Enable Register:

1. Cycling power.
2. *ESE 0

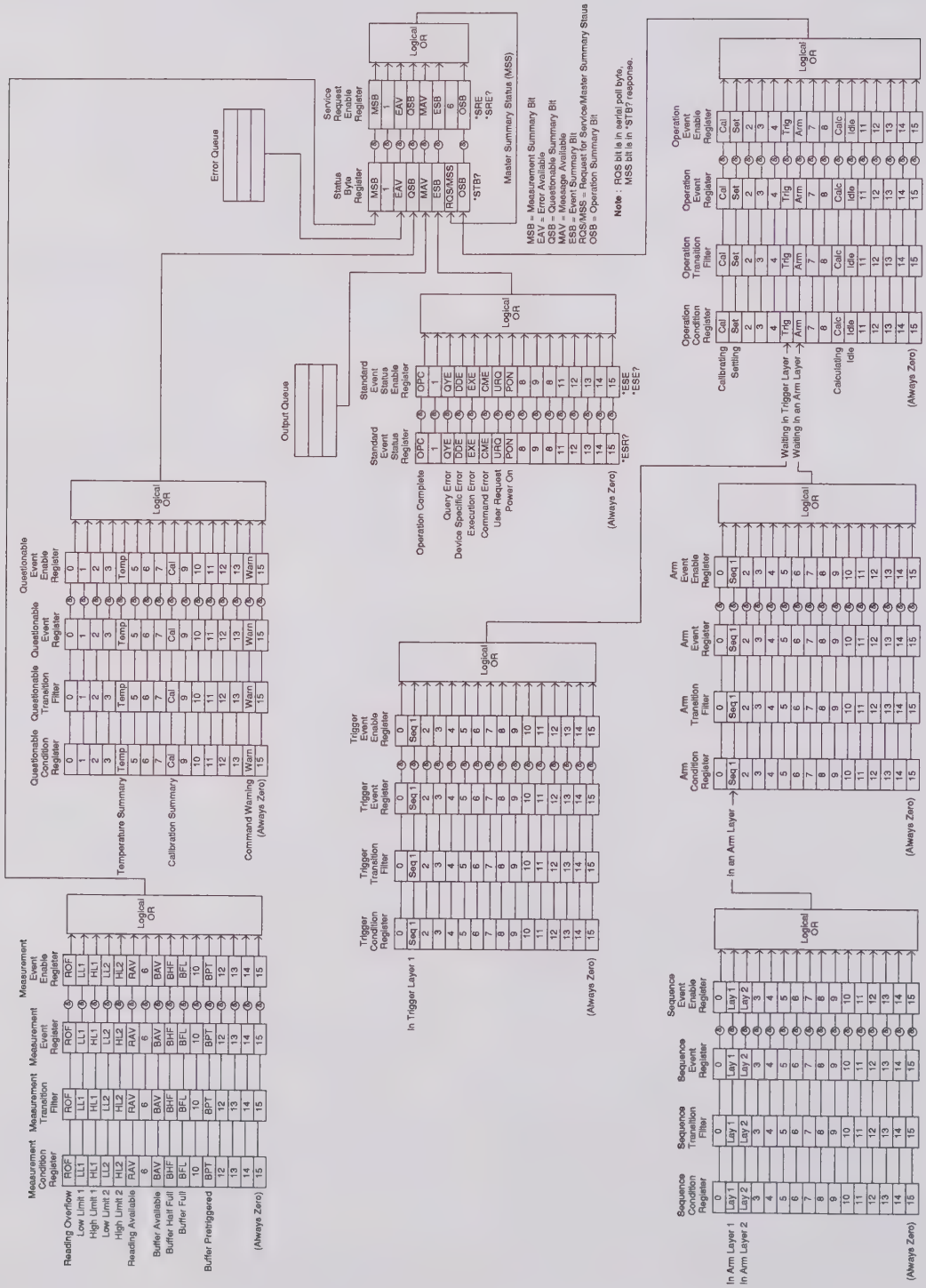


Figure 4-5
Model 2001 status register structure

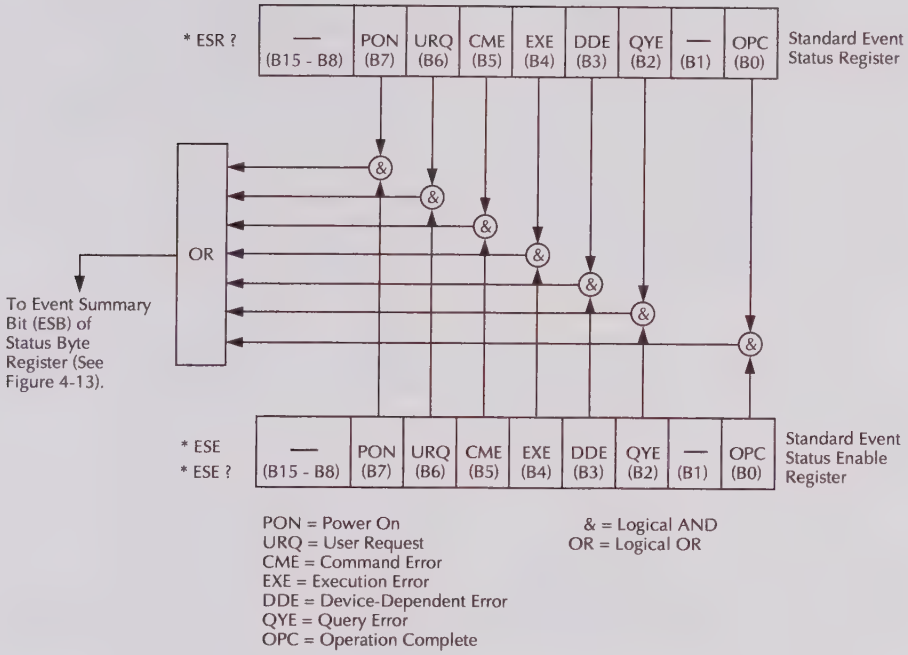


Figure 4-6
Standard event status

4.6.2 Operation event status

The reporting of operation events is controlled by a set of 16-bit registers; the Operation Condition Register, the Transition Filter, the Operation Event Register, and the Operation Event Enable Register. Figure 4-7 shows how these registers are structured.

Notice in Figure 4-5 that bits B5 (Waiting in trigger layer) and B6 (Waiting in an arm layer) of the Operation Condition Register are controlled by the arm register set and the trigger register set (see paragraphs 4.6.3 and 4.6.5 for details). Each of the bits that is used in these registers represent an operation event. Descriptions of the operation event bits are provided in paragraph 4.21.

The operation status registers are controlled by the :STATus:OPERation commands in the :STATus subsystem (see paragraph 4.21).

Operation Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the current operating conditions of the Model 2001. For example, while a calculation is being performed, bit B9 (Calc) of this register will be set. At the completion of the calculation, bit B9 will clear.

The following SCPI query command can be used to read the Operation Condition Register:

:STATus:OPERation:CONDition?

The Operation Condition Register and the Transition Filter are used to set the bits of the Operation Event Register. The Transition Filter is discussed next.

Operation Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Operation Condition Register will set the corresponding bit in the Operation Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Operation Event Register will set when the corresponding bit in the Operation Event Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

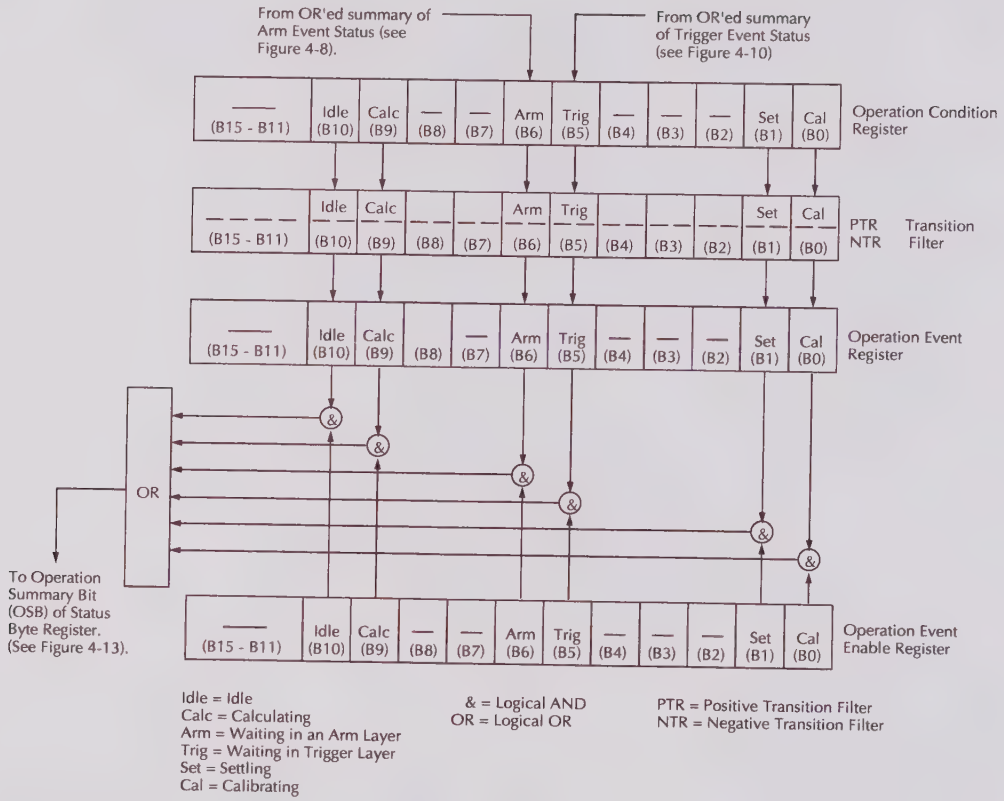

From OR'ed summary of Arm Event Status (see Figure 4-8).
From OR'ed summary of Trigger Event Status (see Figure 4-10)
(B15 - B11) Idle (B10) Calc (B9) (B8) (B7) Arm (B6) Trig (B5) (B4) (B3) (B2) Set (B1) Cal (B0)
Operation Condition Register
PTR NTR Transition Filter
Operation Event Register
OR
To Operation Summary Bit (OSB) of Status Byte Register. (See Figure 4-13).
Operation Event Enable Register
Idle = Idle
Calc = Calculating
Arm = Waiting in an Arm Layer
Trig = Waiting in Trigger Layer
Set = Settling
Cal = Calibrating
& = Logical AND
OR = Logical OR
PTR = Positive Transition Filter
NTR = Negative Transition Filter

Figure 4-7
Operation event status

The individual bits of the transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:OPERation:PTR <NRf>
:STATus:OPERation:NTR <NRf>

The transition filter registers can be read at any time by using the following SCPI query commands:

:STATus:OPERation:PTR?
:STATus:OPERation:NTR?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and clear (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:PTR 65535 and :STATus:OPERation:NTR 0 commands.

Operation Event Register — This is a latched, read-only register whose bits are set by the Operation Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Operation Event Enable Register and applied to an OR gate. The output of the OR gate is the Operation Summary Bit (OSB) that is applied to the Status Byte Register. The following SCPI query command can be used to read the Operation Event Register:

:STATus:OPERation?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Operation Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:EVENt? query command.

Operation Event Enable Register — This register is programmed by the user and serves as a mask for the Operation Event Register. When masked, a set bit in the Operation Event Register will not set the Operation Summary Bit (OSB) in the Status Byte Register. Conversely, when unmasked, a set bit in the Operation Event Register will set the OSB bit.

A bit in the Operation Event Register is masked when the corresponding bit in the Operation Event Enable Register is cleared (0). When the masked bit of the Operation Event Register sets, it is ANDed with the corresponding cleared bit in the Operation Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the OSB bit in the Status Byte Register.

A bit in the Operation Event Register is unmasked when the corresponding bit in the Operation Event Enable Register is set (1). When the unmasked bit of the Operation Event Register sets, it is ANDed with the corresponding set bit in the Operation Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set the OSB bit in the Status Byte Register.

The individual bits of the Operation Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:OPERation:ENABle <NRf>
```

The following SCPI query command can be used to read the Operation Event Enable Register:

```
:STATus:OPERation:ENABle?
```

Reading this register using the above SCPI command does not clear the register. The following list summarizes operations that will clear the Operation Event Enable Register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ENABle 0 command.

4.6.3 Arm event status

The reporting of the arm event is controlled by a set of 16-bit registers; the Arm Condition Register, the Transition Filter, the Arm Event Register, and the Arm Event Enable Register. Figure 4-8 shows how these registers are structured. Notice in Figure 4-5 that bit B1 (In An arm layer) of the Arm Condition Register is controlled by the sequence event register set (see paragraph 4.6.4 for details). In general, bit B1 sets when the instrument is in the arm layer (arm layer 1) or scan layer (arm layer 2) of operation. An explanation of the operation process over bus is provided in paragraph 4.7.

The various registers used for arm event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:ARM commands of the :STATus subsystem (see paragraph 4.21).

Arm Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the ORed summary of the sequence event register set. In general, if bit B1 is set, the instrument is in an arm layer. The following SCPI query command can be used to read the Arm Condition Register:

```
:STATus:OPERation:ARM:CONDition?
```

The Arm Condition Register and the Transition Filter are used to set the bits of the Arm Event Register. The Transition Filter is discussed next.

Arm Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) of bit B1 in the Arm Condition Register will set bit B1 in the Arm Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Arm Event Register will set when the corresponding bit in the Arm Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0. The transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:ARM:PTR <NRf>
:STATus:OPERation:ARM:NTR <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:OPERation:ARM:PTR?
:STATus:OPERation:ARM:NTR?
```

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ARM:PTR 65535 and :STATus:OPERation:ARM:NTR 0 commands.

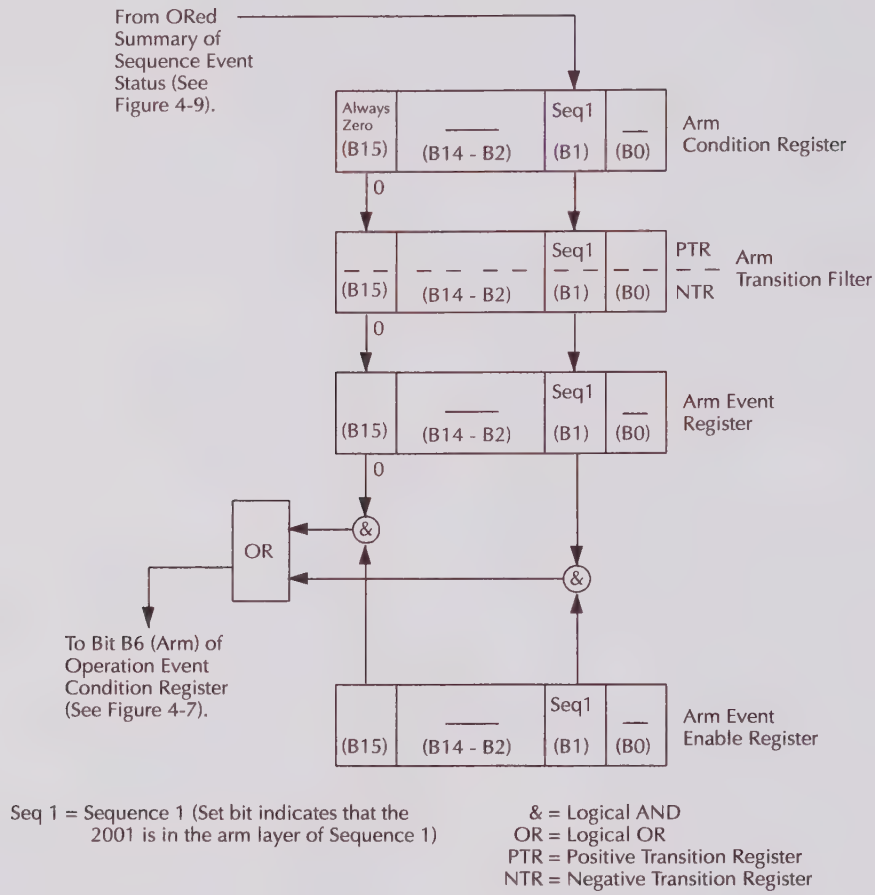


Figure 4-8
Arm event status

Arm Event Register — This is a latched, read-only register whose bits are set by the Arm Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Arm Event Enable Register and applied to an OR gate. The output of the OR gate is the Arm Summary Bit that is applied to the Operation Condition Register. The following SCPI query command can be used to read the Arm Event Register:

:STATus:OPERation:ARM:EVENt?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Operation Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:ARM? query command.

Arm Event Enable Register — This register is programmed by the user and serves as a mask for the Arm Event Register. When masked, a set bit (B1) in the Arm Event Register will not set the Waiting for Arm bit in the Operation Condition Register. Conversely, when unmasked, a set bit (B1) in the Arm Event Register will set the Waiting for Arm bit.

Bit B1 in the Arm Event Register is masked when the corresponding bit (B1) in the Arm Event Enable Register is cleared (0). When the masked bit of the Arm Event Register sets, it is ANDed with the corresponding cleared bit in the Arm Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the Waiting for Arm bit in the Operation Condition Register.

Bit B1 in the Arm Event Register is unmasked when the corresponding bit (B1) in the Arm Event Enable Register is set (1). When the unmasked bit of the Arm Event Register sets, it is ANDed with the corresponding set bit in the Arm Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set the Waiting for Arm bit in the Operation Condition Register.

Bit B1 of the Arm Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:ARM:ENABle <NRf>

The following SCPI query command can be used to read the Arm Event Enable Register:

:STATus:OPERation:ARM:ENABle?

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Arm Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:ARM:ENABle 0 command.

4.6.4 Sequence event status

The reporting of sequence events is controlled by a set of 16-bit registers; the Sequence Condition Register, the Transition Filter, the Sequence Event Register and the Sequence Event Enable Register. Figure 4-9 shows how these registers are structured.

Two bits of this register set are used by the Model 2001 to report sequence events. Bit B1 (In arm layer 1) is set when instrument is in (or exited) the arm layer (arm layer 1) of operation. Bit B2 (In arm layer 2) is set when the instrument is in (or exited) the scan layer (arm layer 2). The operation process over the bus is explained in paragraph 4.7.

The various registers used for sequence event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:ARM:SEQuence commands of the :STATus subsystem (see paragraph 4.21).

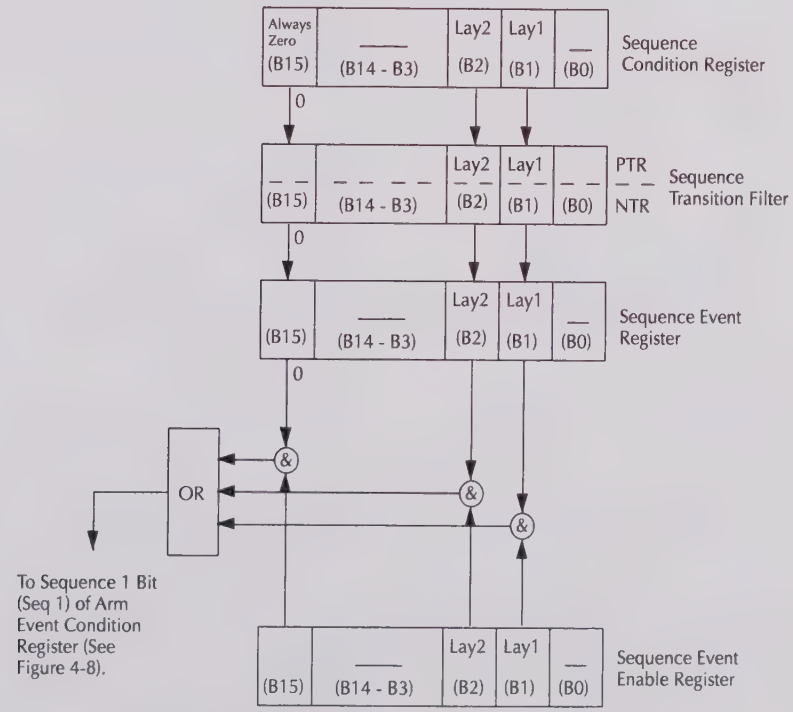


Figure 4-9
Sequence event status

Sequence Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the current arm layer status of the instrument. For example, if the Model 2001 is currently in the scan layer of operation, bit B2 (In arm layer 2) of this register will be set.

The following SCPI query command can be used to read the Sequence Condition Register:

```
:STATus:OPERation:ARM:SEQuence:CONDition?
```

The Sequence Condition Register and the Transition Filter are used to set the bits of the Sequence Event Register. The Transition Filter is discussed next.

Sequence Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Sequence Condition Register will set the corresponding bit in the Sequence Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Sequence Event Register will set when the corresponding bit in the Sequence Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>
:STATus:OPERation:ARM:SEQuence:NTRansition <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:OPERation:ARM:SEQuence:PTRansition?
:STATus:OPERation:ARM:SEQuence:NTRansition?
```

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ARM:SEQuence:PTR 65535 and :STATus:OPERation:ARM:SEQuence:NTR 0 commands.

Sequence Event Register — This is a latched, read-only register whose bits are set by the Sequence Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing sequence. The bits of this register are logically ANDed with the bits of the Sequence Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B1 of the Arm Condition Register (see paragraph 4.6.3). The following SCPI query command can be used to read the Sequence Event Register:

```
:STATus:OPERation:ARM:SEQuence?
```

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Sequence Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:ARM:SEQuence? query command.

Sequence Event Enable Register — This register is programmed by the user and serves as a mask for the Sequence Event Register. When masked, a set bit in the Sequence Event Register will not set bit B1 of the Arm Condition Register. Conversely, when unmasked, a set bit in the Sequence Event Register will set the bit B1 of the Arm Condition Register.

A bit in the Sequence Event Register is masked when the corresponding bit in the Sequence Event Enable Register is cleared (0). When the masked bit of the Sequence Event Register sets, it is ANDed with the corresponding cleared bit in the Sequence Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set bit B1 of the Arm Condition Register.

A bit in the Sequence Event Register is unmasked when the corresponding bit in the Sequence Event Enable Register is set (1). When the unmasked bit of the Sequence Event Register sets, it is ANDed with the corresponding set bit in the Sequence Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set bit B1 of the Arm Condition Register.

The individual bits of the Sequence Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:OPERation:ARM:SEQuence:ENABle <NRf>
```

The following SCPI query command can be used to read the Sequence Event Enable Register:

```
:STATus:OPERation:ARM:SEQuence:ENABle?
```

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Sequence Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:ARM:SEQuence:ENABle 0 command.

4.6.5 Trigger event status

The reporting of the trigger event is controlled by a set of 16-bit registers; the Trigger Condition Register, the Transition Filter, the Trigger Event Register, and the Trigger Event Enable Register. Figure 4-10 shows how these registers are structured.

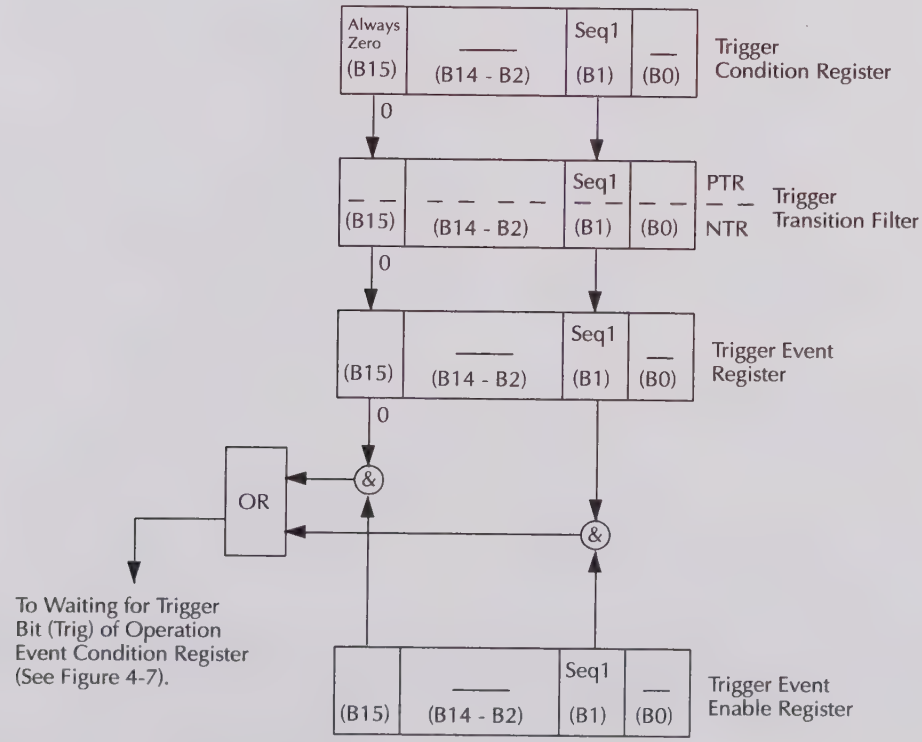
Bit B1 (Seq1) of the register set is used for the trigger event (In trigger layer of Sequence 1). In general, Bit B1 sets when the instrument is in (or has exited) the measure layer of operation. An explanation of the Model 2001 operation process is provided in paragraph 4.7. The various registers used for trigger event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:TRIGger commands of the :STATus subsystem (see paragraph 4.21).

Trigger Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the trigger layer status of the instrument. If bit B1 is set, the instrument is in the trigger layer (measure layer) of operation.

The following SCPI query command can be used to read the Trigger Condition Register:

:STATus:OPERation:TRIGger:CONDition?

The Trigger Condition Register and the Transition Filter are used to set bit B1 of the Trigger Event Register. The Transition Filter is discussed next.



Seq 1 = Sequence 1 (Set bit indicates that the 2001 is in the trigger layer of Sequence 1)

& = Logical AND
OR = Logical OR
PTR = Positive Transition Register
NTR = Negative Transition Register

Figure 4-10
Trigger event status

Trigger Event Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) of bit B1 in the Trigger Condition Register will set bit B1 in the Trigger Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Trigger Event Register will set when the corresponding bit in the Trigger Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:TRIGger:PTRansition  <NRf>
:STATus:OPERation:TRIGger:NTRansition  <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:OPERation:TRIGger:PTRansition?
:STATus:OPERation:TRIGger:NTRansition?
```

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

Cycling power.

1. Sending the :STATus:PRESet command.
2. Sending the :STATus:OPERation:TRIGger:PTR 65535 and :STATus:OPERation:TRIGger:NTR 0 commands.

Trigger Event Register — This is a latched, read-only register whose bits are set by the Trigger Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Trigger Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B5 (Waiting for Trigger) of the Operation Condition Register.

The following SCPI query command can be used to read the Trigger Event Register:

```
:STATus:OPERation:TRIGger:EVENt?
```

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Trigger Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:TRIGger? query command.

Trigger Event Enable Register — This register is programmed by the user and serves as a mask for the Trigger Event Register. When masked, a set bit (B1) in the Trigger Event Register cannot set bit B5 (Waiting for Trigger) of the Operation Condition Register. Conversely, when unmasked, a set bit (B1) in the Trigger Event Register will set bit B5 of the Operation Condition Register.

Bit B1 in the Trigger Event Register is masked when the corresponding bit (B1) in the Trigger Event Enable Register is cleared (0). When the masked bit of the Trigger Event Register sets, it is ANDed with the corresponding cleared bit in the Trigger Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, cannot set bit B5 of the Operation Condition Register.

Bit B1 in the Trigger Event Register is unmasked when the corresponding bit (B1) in the Trigger Event Enable Register is set (1). When the unmasked bit of the Trigger Event Register sets, it is ANDed with the corresponding set bit in the Trigger Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set bit B5 of the Operation Condition Register.

Bit B1 of the Trigger Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:OPERation:TRIGger:ENABle  <NRf>
```

The following SCPI query command can be used to read the Trigger Event Enable Register:

```
:STATus:OPERation:TRIGger:ENABle?
```

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Trigger Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:TRIGger:ENABle 0 command.

4.6.6 Measurement event status

The reporting of measurement events is controlled by a set of 16-bit registers; the Measurement Event Condition Register, the Transition Filter, the Measurement Event Status Register and the Measurement Event Enable Register. Figure 4-11 shows how these registers are structured. Each of the bits that is used in these registers represent a measurement event. Descriptions of the measurement event bits are provided in paragraph 4.21.

The measurement status registers are controlled by the :STATus:MEASurement commands in the :STATus subsystem (see paragraph 4.21).

Measurement Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the current operating conditions of the Model 2001. For example, when the trace buffer becomes full, bit B9 (BFL) of this register will be set. When the buffer is not full, bit B9 will clear.

The following SCPI query command can be used to read the Measurement Condition Register:

:STATus:MEASurement:CONDition?

The Measurement Condition Register and the Transition Filter are used to set the bits of the Measurement Event Register. The Transition Filter is discussed next.

Measurement Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Measurement Condition Register will set the corresponding bit in the Measurement Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Measurement Event Register will set when the corresponding bit in the Measurement Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the

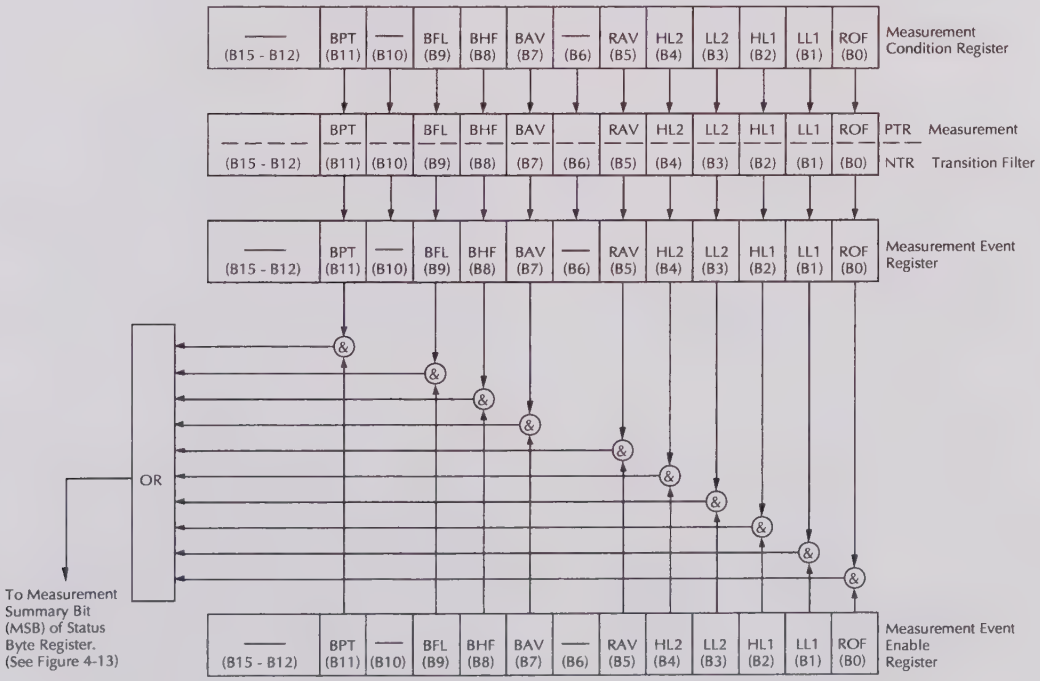


Figure 4-11
Measurement event status

bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The individual bits of the transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:MEASurement:PTR  <NRf>
:STATus:MEASurement:NTR  <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:MEASurement:PTR?
:STATus:MEASurement:NTR?
```

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and clear (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:MEASurement:PTR 65535 and :STATus:MEASurement:NTR 0 commands.

Measurement Event Register — This is a latched, read-only register whose bits are set by the Measurement Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Measurement Event Enable Register and applied to an OR gate. The output of the OR gate is the Measurement Summary Bit (MSB) of the Status Byte Register. The following SCPI query command can be used to read the Measurement Event Register:

```
:STATus:MEASurement:EVENt?
```

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Measurement Event Status Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:MEASurement? query command.

Measurement Event Enable Register — This register is programmed by the user and serves as a mask for the Measurement Event Register. When masked, a set bit in the Measurement Event Register will not set the Measurement Summary Bit (MSB) in the Status Byte Register. Conversely, when unmasked, a set bit in the Measurement Event Register will set the MSB bit.

A bit in the Measurement Event Register is masked when the corresponding bit in the Measurement Event Enable Register is cleared (0). When the masked bit of the Measurement Event Register sets, it is ANDed with the corresponding cleared bit in the Measurement Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the MSB bit in the Status Byte Register.

A bit in the Measurement Event Register is unmasked when the corresponding bit in the Measurement Event Enable Register is set (1). When the unmasked bit of the Measurement Event Register sets, it is ANDed with the corresponding set bit in the Measurement Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set the MSB bit in the Status Byte Register.

The individual bits of the Measurement Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:MEASurement:ENABle  <NRf>
```

The following SCPI query command can be used to read the Measurement Event Enable Register:

```
:STATus:MEASurement:ENABle?
```

Reading this register using the above SCPI command does not clear the register. The following list summarizes operations that will clear the Measurement Event Enable Register:

1. Cycling power.
2. Sending the :STATus:MEASurement:ENABle 0 command.

4.6.7 Questionable event status

The reporting of questionable events is controlled by a set of 16-bit registers; the Questionable Condition Register, the Transition Filter, the Questionable Event Register and the Questionable Event Enable Register. Figure 4-12 shows how these registers are structured. Each of the bits that is used in these registers represent a questionable event. Descriptions of the questionable event bits are provided in paragraph 4.21.

The questionable status registers are controlled by the :STATus:QUEStionable commands in the :STATus subsystem (see paragraph 4.21).

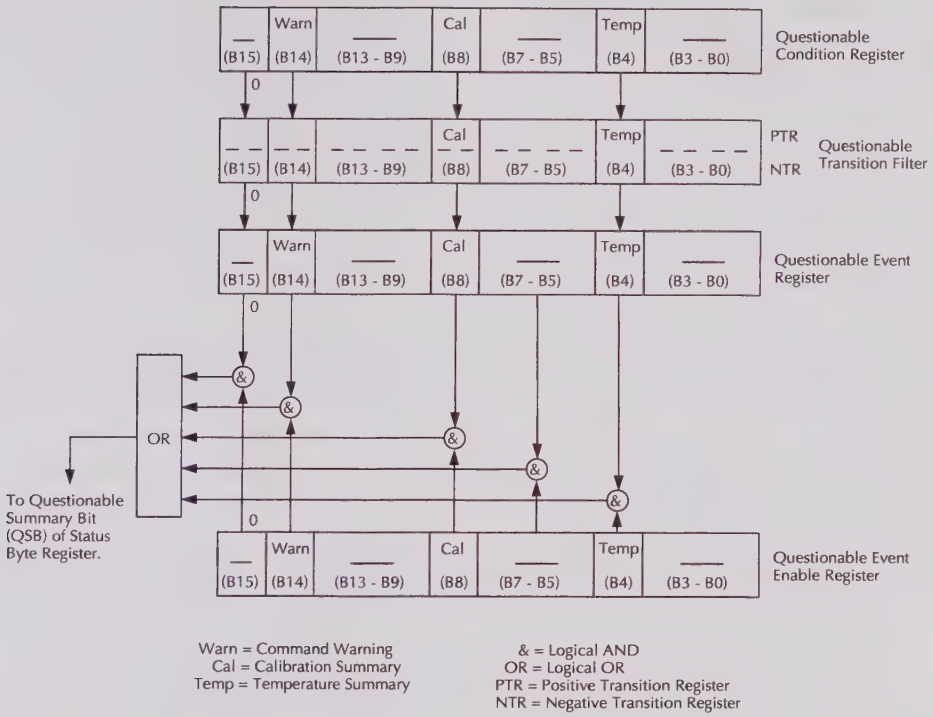


Figure 4-12
Questionable event status

Questionable Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the current operating conditions of the Model 2001. For example, when a calibration summary event occurs, bit B8 (Cal) will set. When the event is no longer true, bit B8 will clear.

The following SCPI query command can be used to read the Questionable Condition Register:

:STATus:QUEStionable:CONDition?

The Questionable Condition Register and the Transition Filter are used to set the bits of the Questionable Event Register. The Transition Filter is discussed next.

Questionable Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Questionable Condition Register will set the corresponding bit in the Questionable Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Questionable Event Register will set when the corresponding bit in the Questionable Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The individual bits of the transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:QUEStionable:PTR <NRf>
:STATus:QUEStionable:NTR <NRf>

The transition filter registers can be read at any time by using the following SCPI query commands:

:STATus:QUEStionable:PTR?
:STATus:QUEStionable:NTR?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and clear (0) all the bits of the NTR register:

1. Cycling power.

2. Sending the :STATus:PRESet command.
3. Sending the :STATus:QUEStionable:PTR 65535 and :STATus:QUEStionable:NTR 0 commands.

Questionable Event Register — This is a latched, read-only register whose bits are set by the Questionable Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Questionable Event Enable Register and applied to an OR gate. The output of the OR gate is the Questionable Summary Bit (QSB) of the Status Byte Register. The following SCPI query command can be used to read the Questionable Event Register:

```
:STATus:QUEStionable:EVENt?
```

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Questionable Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:QUEStionable? query command.

Questionable Event Enable Register — This register is programmed by the user and serves as a mask for the Questionable Event Register. When masked, a set bit in the Questionable Event Register will not set the Questionable Summary Bit (QSB) in the Status Byte Register. Conversely, when unmasked, a set bit in the Questionable Event Register will set the QSB bit.

A bit in the Questionable Event Register is masked when the corresponding bit in the Questionable Event Enable Register is cleared (0). When the masked bit of the Questionable Event Register sets, it is ANDed with the corresponding cleared bit in the Questionable Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the QSB bit in the Status Byte Register.

A bit in the Questionable Event Register is unmasked when the corresponding bit in the Questionable Event Enable Register is set (1). When the unmasked bit of the Questionable Event Register sets, it is ANDed with the corresponding set bit in the Questionable Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set the QSB bit in the Status Byte Register.

The individual bits of the Questionable Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:QUEStionable:ENABle <NRf>
```

The following SCPI query command can be used to read the Questionable Event Enable Register:

```
:STATus:QUEStionable:ENABle?
```

Reading this register using the above SCPI command does not clear the register. The following list summarizes operations that will clear the Questionable Event Enable Register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:QUEStionable:ENABle 0 command.

4.6.8 Queues

The Model 2001 uses two queues; the Output Queue and the Error Queue. The queues are first-in first-out (FIFO) registers. The Output Queue is used to hold readings and data messages, and the Error Queue is used to hold error messages and status messages. The Model 2001 Status Model (Figure 4-5) shows how the two queues are structured with the other registers.

Output Queue — The Output Queue is used to hold readings and all data that pertains to the normal operation of the instrument. For example, when a query command is sent, the data message that pertains to that query is placed in the Output Queue.

When a data message is placed in the Output Queue, the Message Available (MAV) bit in the Status Byte Register becomes set. A data message is cleared from the Output Queue when it is read. The Output Queue is considered cleared when it is empty. An empty Output Queue clears the MAV bit in the Status Byte Register.

A message from the Output Queue is read by addressing the Model 2001 to talk after the appropriate query message is sent. The following programming example in HP BASIC 4.0 sends a query command, sends the data message to the computer, and then displays it on the CRT.

```
10 OUTPUT 716; "*IDN?" !Request identification code.
20 ENTER 716; A$       !Address 2001 to talk.
30 PRINT A$            !Display ID code.
40 END
```

Error Queue — The Error Queue is used to hold error messages and status messages. When an error or status event occurs, a message that defines the error/status is placed in the Error Queue. This queue will hold up to 10 messages.

When a message is placed in the Error Queue, the Error Available (EAV) bit in the Status Byte Register is set. An error message is cleared from the Error/Status Queue when it is read. The Error Queue is considered cleared when it is empty. An empty Error Queue clears the EAV bit in the Status Byte Register. An error message from the Error Queue is read by sending either of the following SCPI query commands and then addressing the Model 2001 to talk:

```
:SYSTem:ERRor?
:STATus:QUEue?
```

Refer to paragraphs 4.21 (:STATus:QUEue?) and 4.22 (:SYSTem:ERRor?) for complete information on reading error messages.

4.6.9 Status byte and service request (SRQ)

Service request is controlled by two 8-bit registers; the Status Byte Register and the Service Request Enable Register. The structure of these registers is shown in Figure 4-13.

Status Byte Register — The summary messages from the status registers and queues are used to set or clear the appropriate bits (B0, B2, B3, B4, B5 and B7) of the Status Byte Register. These bits do not latch and their states (0 or 1) are solely dependent on the summary messages (0 or 1). For example, if the Standard Event Status Register is read, its register will clear. As a result, its summary message will reset to 0, which in turn will clear the ESB bit in the Status Byte Register.

Bit B6 in the Status Byte Register is either:

- The Master Summary Status (MSS) bit, sent in response to the *STB? command, indicates the status of any set bits with corresponding enable bits set.
- The Request for Service (RQS) bit, sent in response to a serial poll, indicates which device was requesting service by pulling on the SRQ line.

For description of the other bits in the Status Byte Register, refer to paragraph 4.10.14.

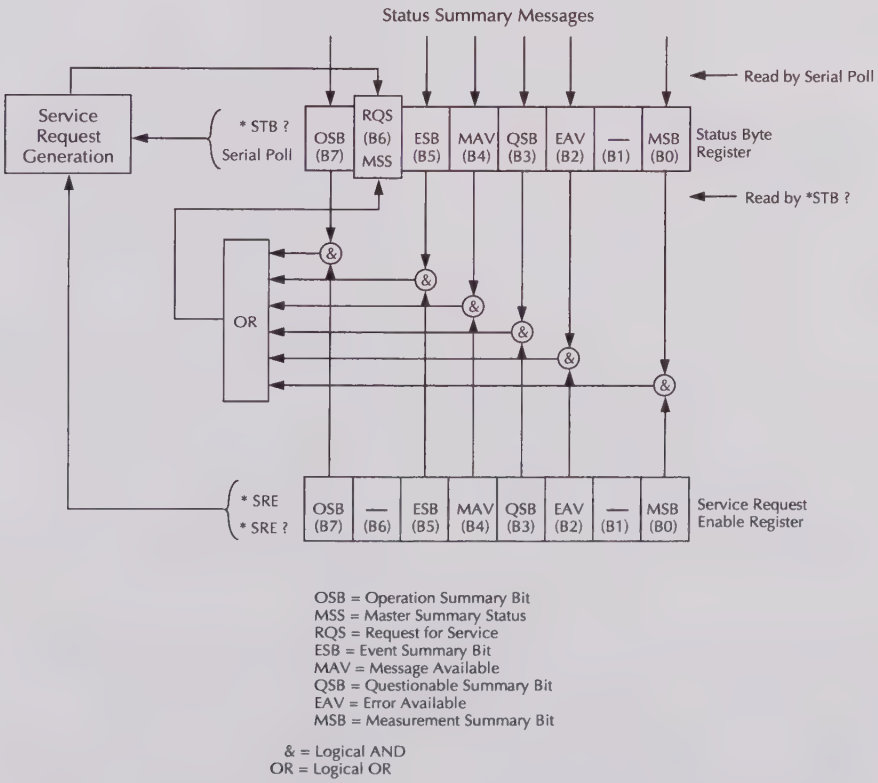


Figure 4-13
Status byte and service request (SRQ)

The IEEE-488.2 standard uses the following common query command that simply reads the Status Byte Register contents:

*STB?

When reading the Status Byte Register using the *STB? command, bit B6 is called the MSS bit. None of the bits in the Status Byte Register are cleared when using the *STB? command to read it.

The IEEE-488.1 standard has a serial poll sequence that will also read the Status Byte Register and is better suited to detect a service request (SRQ). When using the serial poll, bit B6 is called the RQS bit. Serial polling causes bit B6 (RQS) to reset. Serial polling is discussed in more detail later in this paragraph (see "Serial Poll and SRQ").

The following operations clear all bits of the Status Byte Register:

1. Cycling power.
2. Sending the *CLS common command.

NOTE

The MAV bit may or may not be cleared.

Service Request Enable Register — This register is programmed by the user and serves as a mask for the Status Summary Message bits (B0, B2, B3, B4, B5 and B7) of the Status Byte Register. When masked, a set summary bit in the Status Byte Register will not set bit B6 (MSS/RQS) of the Status Byte Register. Conversely, when unmasked, a set summary bit in the Status Byte Register will set bit B6.

A Status Summary Message bit in the Status Byte Register is masked when the corresponding bit in the Service Request Enable Register is cleared (0). When the masked summary bit in the Status Byte Register sets, it is ANDed with the corresponding cleared bit in the Service Request Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the MSS/RQS bit in the Status Byte Register.

A Status Summary Message bit in the Status Byte Register is unmasked when the corresponding bit in the Service Request Enable Register is set (1). When the unmasked summary bit in the Status Byte Register sets, it is ANDed with the corresponding set bit in the Service Request Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set the MSS/RQS bit in the Status Byte Register.

The individual bits of the Service Request Enable Register can be set or cleared by using the following common command (see paragraph 4.10.12 for details):

*SRE <NRf>

The Service Request Enable Register can be read using the following common query command (see paragraph 4.10.13 for details):

*SRE?

The Service Request Enable Register is not cleared when it is read using the *SRE? query command. The Service Request Enable Register will clear when power is cycled or a parameter (n) value of zero is sent with the *SRE command (*SRE 0).

Serial poll and SRQ

Any enabled event summary bit that goes from 0 to 1 will set RQS and generate a service request (SRQ). The user's test program can periodically read the Status Byte Register to check to see if a service request (SRQ) has occurred and what caused it. In the event of an SRQ, the program can, for example, branch to an appropriate subroutine that will service the request. Typically, service requests (SRQs) are managed by the serial poll sequence of the Model 2001. If an SRQ does not occur, bit B6 (RQS) of the Status Byte Register will remain cleared and the program will simply proceed normally after the serial poll is performed. If an SRQ does occur, bit B6 of the Status Byte Register will set and the program can branch to a service subroutine when the SRQ is detected by the serial poll.

The serial poll will automatically reset RQS of the Status Byte Register. This will allow subsequent serial polls to monitor Bit 6 for an SRQ occurrence generated by other event types. After a serial poll, the same event can cause another SRQ, even if the event register which caused the first SRQ has not been cleared.

A serial poll clears RQS but does not clear MSS. The MSS bit will stay set until all Status Byte event summary bits are cleared.

The following HP BASIC 4.0 programming example demonstrates how a serial poll can be used to detect an SRQ.

```
10 REMOTE 716
20 CLEAR 716
30 OUTPUT 716; "*ESE 32" ! Unmask command error
                           bit (B5) in Standard Event
                           Enable Register.
```

```
 40 OUTPUT 716; "*SRE 32" ! Unmask event summary
                            bit (B5) in Service Re-
                            quest Enable Register.
 50 OUTPUT 716; "*ESE"    ! Program command error
                            (missing parameter) to
                            generate SRQ.
 60 WAIT 1
 70 S=SPOLL (716)         ! Serial poll 2001.
 80 IF BIT (S,6) THEN Service!Go to Service (line 200).
 90 END
200 SUB Service
210 PRINT "B7 B6 B5 B4 B3  !Identify bits.
    B2 B1 B0"
220 FOR I = 7 TO 0 STEP -1 ! Loop eight times.
230 PRINT BIT (S,I)        ! Display bit values
240 NEXT I
250 SUBEND
```

Program analysis:

Line 10	Place 2001 in remote.
Line 20	Perform a device clear.
Line 30	Set bit B5 of Standard Event Enable Register. This unmasks the command error event.
Line 40	Set bit B5 of the Service Request Enable Register. This unmasks the event summary message.
Line 50	Send an illegal command in order to generate an SRQ.
Line 60	Wait for a second to ensure completion of command execution.
Line 70	If SRQ occurred, bit B6 in Status Byte Register will be set and program will go to Service subroutine.
Line 200 to 240	Service subroutine displays the bit values (0 or 1) of the Status Byte Register. For this example, bit B5 (ESB) and bit B6 (RQS) will be set.

The actual serial poll sequence is explained in paragraph 4.6.9.

4.7 Trigger Model (IEEE-488 operation)

The following information describes the operation process of the Model 2001 over the IEEE-488 bus. The flowchart in Figure 4-14, which summarizes operation over the bus, is called the Trigger Model. It is called the Trigger Model because operation is controlled by SCPI commands from the Trigger subsystem (see paragraph 4.24). Notice that key SCPI commands are included in the Trigger Model.

Idle and initiate

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the Trigger Model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform any measure or scan functions. Over the bus, there are two SCPI commands that can be used to take the instrument out of the idle state; :INITiate or :INITiate:CONTinuous ON.

Notice that with continuous initiation enabled (:INIT:CONT ON), the instrument will not remain in the idle state after all programmed operations are completed. However, the instrument can be returned to the idle state at any time by sending the *RST command, the *RCL command, or the SYST:PRES command.

Once the instrument is taken out of the idle state, operation proceeds into the arm layer (arm layer 1) of the Trigger Model.

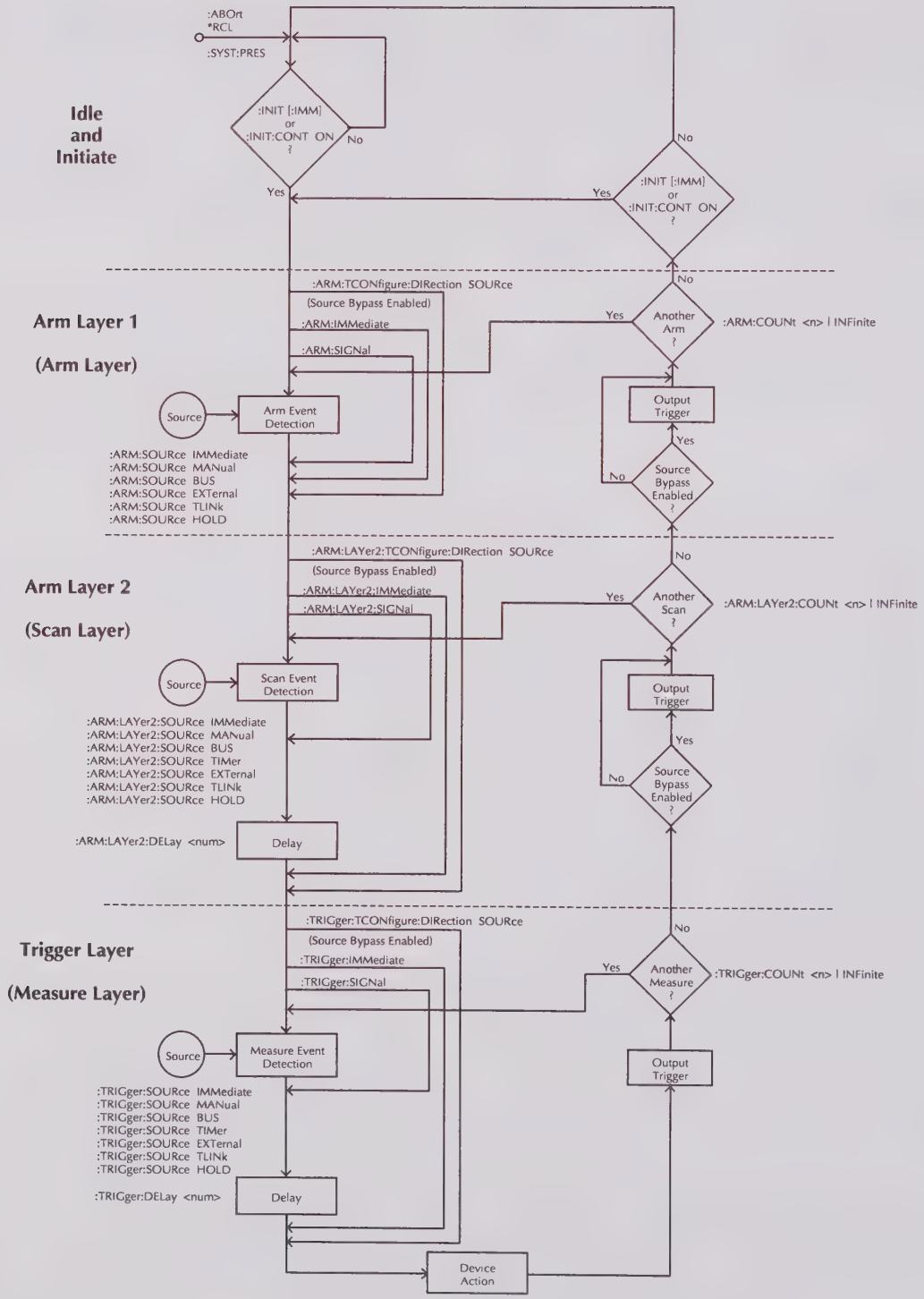


Figure 4-14
Trigger Model (IEEE-488 bus operation)

Arm layer1

NOTE

For front panel operation, this layer is called the arm layer.

In general, the instrument requires an arm event to allow operation to proceed to the next layer (arm layer 2). With the Immediate control source selected (:ARM:SOURce IMMediate), operation immediately proceeds to the next layer when the instrument is taken out of the idle state. The *RST and :SYSTem:PRESet commands also set the arm control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Manual control source selected (:ARM :SOURce MANual), the instrument will wait until the front panel TRIG key is pressed. Note that the Model 2001 must be taken out of remote (press LOCAL key or send LOCAL 716 over bus) before it will respond to the TRIG key. With the Bus control source selected (:ARM:SOURce BUS), the instrument will wait until a bus trigger (GET or *TRG) is received. With the External control source selected (:ARM:SOURce EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:ARM:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:SOURce HOLD), the instrument will not respond to any of the control source events.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through arm layer 1. If programmed for another arm (arm count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes into Idle.

   Enabling the Source Bypass also enables the Output Trigger. When operation returns to arm layer 1 from arm layer 2, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other control source selections, the output trigger pulse will be available at the METER COMPLETE connector. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM :TCONfigure:DIRection ACCeptor).
2. Each time the :ARM:IMMediate command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).
3. Each time the :ARM:SIGNal command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).

After all other instrument operations have been completed, the instrument can be returned to arm layer 1 by programming the instrument for additional arms. The :ARM:COUNt <n>|INFinite command can be used to set the arm count to a finite value (where n = 1 to 99999) or for an infinite (INF) number of arms. The *RST and :SYSTem:PRESet commands set the arm count to 1.

After the instrument leaves arm layer 1, operation proceeds into the scan layer (arm layer 2).

Arm layer2

NOTE

For front panel operation, this layer is called the scan layer.

In general, the instrument requires a scan event to allow operation to proceed to the next layer (trigger layer). With the Immediate control source selected (:ARM:LAYer2:SOURce IMMediate), operation immediately proceeds to the next layer. The *RST and :SYSTem:PRESet commands also set the scan control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:ARM:LAYer2SOURce TIMer), operation will immediately proceed into the trigger layer on the initial pass through arm layer 2. Each additional scan will not occur until the programmed timer interval elapses. The timer can be set to an interval from 1msec to 999999.999 seconds.

With the Manual control source selected (:ARM:LAYer2:SOURce MANual), the instrument will wait until the front panel TRIG key is pressed. Note that the Model 2001 must be taken out of remote (press LOCAL key or send LOCAL 716 over bus) before it will respond to the TRIG key. With the Bus control source selected

(:ARM:LAYer2:SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the External control source selected (:ARM:LAYer2:SOURce EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:ARM:LAYer2:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:LAYer2:SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed scan event is detected, the instrument will wait for the programmed Delay to time out. The :ARM:LAYer2:DELay <num> command is used to set the Delay (where num = 0 to 999999.999 seconds). The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. Two of these paths also loop around the Delay. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through arm layer 2. If programmed for another scan (scan count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back into arm layer 1.

   Enabling the Source Bypass also enables the Output Trigger. When operation returns to arm layer 2 from the trigger layer, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other control source selections, the output trigger pulse will be available at the METER COMPLETE connector. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM:TCONfigure:DIRection ACCeptor).
2. Each time the :ARM:LAYer2:IMMediate command is sent, operation will loop around the scan control source and the Delay. It is used when you do not wish to wait for a programmed scan event to occur (or when the Hold control source is selected).
3. Each time the :ARM:LAYer2:SIGNal command is sent, operation will loop around the scan control source. This path functions the same as :ARM:LAYer2:IMMediate except that it does not loop around the Delay.

After all other operations in the next layer have been completed, the instrument can be returned to arm layer 2 by programming the instrument for additional scans. The :ARM:LAYer2:COUNt <n>|INFinite command can be used to set the scan count to a finite value (where n = 1 to 99999) or for an infinite (INF) number of scans. The *RST command sets the scan count to one and the :SYSTem:PRESet command sets the scan count to infinite.

After the instrument leaves arm layer 2, operation proceeds to the measure layer (trigger layer).

Trigger layer

NOTE

For front panel operation, this layer is called the measure layer.

In general, measure events control the measurement (or scan) rate. With the Immediate control source selected (:TRIGger:SOURce IMMediate), operation immediately proceeds to the Delay. The *RST command also sets the measure control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:TRIGger :SOURce TIMer), the first measurement will occur immediately. Each additional measurement will occur at a rate determined by the programmed timer interval (1msec to 999999.999 seconds).

With the Manual control source selected (:TRIGger :SOURce MANual), the instrument will wait until the front panel TRIG key is pressed. Note that the Model 2001 must be taken out of remote (press LOCAL key or send LOCAL 716 over bus) before it will respond to the TRIG key. The :SYSTem:PRESet command also selects the Immediate control source.

With the Bus control source selected (:TRIGger :SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the External control source selected (:TRIGger:SOURCE EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:TRIGger:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected

(:TRIGger :SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed measure event is detected, the instrument will wait for the programmed Delay to time out. The :TRIGger:DELay <num> command is used to set the Delay (where num = 0 to 999999.999 seconds).

The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. Two of these paths also loop around the Delay. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM :TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through the trigger layer. If programmed to perform another measurement, (measure count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back to arm layer 2.
2. Each time the :TRIGger:IMMediate command is sent, operation will loop around the control source and the Delay. It is used when you do not wish to wait for a programmed measure event to occur (or when the Hold control source is selected).
3. Each time the :TRIGger:SIGNal command is sent, operation will loop around the measure control source. This path functions the same as :TRIGger:IMMediate except that it does not loop around the Delay.

At this point a measurement will be performed (Device Action). Note that the Device Action could include a function change and a channel scan (if scanner is enabled). A channel is scanned (closed) before a measurement is taken. When scanning channels, the previous channel will open and the next channel will close (break-before-make). Also included in the Device Action is the internal settling time delay for the relay.

After a channel is scanned, an Output Trigger will occur. If the measure control source is programmed for Immediate, Manual, Bus or Timer, the output trigger pulse will be available at the METER COMPLETE connector. If the Trigger Link control source is selected, Output Trigger action will occur as follows:

1. If the asynchronous Trigger Link mode is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line.
2. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (:trig :tcon:dir acc), the Trigger Link line will be released (goes high).
3. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is enabled (:trig :tcon:dir sour), the Trigger Link line will be pulled down low and then released.

NOTE: See paragraph 3.7.7 for details on using the Trigger Link.

After the Device Action and an output trigger occurs, the instrument will (if programmed to do so) return to the beginning of the trigger layer to perform another measurement. The :TRIGger:COUNt <n>|INFinite command is used to set the measure count to a finite value (where n = 1 to 99999) or for continuous measurements (INFinite). The *RST and :SYSTem:PRESet commands set the measure count to one.

4.8 General bus commands

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument. Commands supported by the Model 2001 are listed in Table 4-3 which also lists BASIC statements necessary to send each command. Note that commands requiring that a primary address be specified assume that the primary address is set to 16. This is the address that is set at the factory.

Table 4-3
General bus commands and associated BASIC statements

Command	HP BASIC 4.0 statement	Effect on Model 2001
REN	REMOTE 7	Goes into effect when next addressed to listen.
IFC	ABORT 7	Goes into talker and listener idle states.
LLO	LOCAL LOCKOUT 7	LOCAL key locked out.
GTL	LOCAL 716	Cancel remote, restore front panel operation.
DCL	CLEAR 7	Returns all devices to known conditions.
SDC	CLEAR 716	Returns Model 2001 to known conditions.
GET	TRIGGER 716	Initiates a trigger.
SPE, SPD	SPOLL (716)	Serial Polls the Model 2001.

4.8.1 REN (remote enable)

The remote enable command is sent to the Model 2001 by the controller to set up the instrument for remote operation. Generally, the instrument should be placed in the remote mode before you attempt to program it over the bus. Simply setting REN true does not actually place the instrument in the remote state. Instead the instrument must be addressed to listen after setting REN true before it goes into remote.

Note that the instrument need not be in remote to be a talker.

Programming example — This sequence is automatically performed by the controller when the following is typed into the keyboard:

```
REMOTE 716
```

After the RETURN key is pressed, the instrument is in the remote state, as indicated by the REM annunciator. If not, check to see that the instrument is set to the primary address 16, and check to see that the bus connections are properly made.

Note that all front panel controls except for LOCAL (and POWER) are inoperative while the instrument is in remote. You can restore normal front panel operation by pressing the LOCAL key.

4.8.2 IFC (interface clear)

The IFC command is sent by the controller to place the Model 2001 in the local, talker, and listener idle states. The unit responds to the IFC command by cancelling front panel TALK or LISTEN lights, if the instrument was previously placed in one of those states.

Note that this command does not affect the status of the instrument; settings, data, and event registers are not changed.

To send the IFC command, the controller need only set the IFC line true for a minimum of 100μsec.

Programming example — Before demonstrating the IFC command, turn on the TALK indicator with the following statement:

```
ENTER 716; A$
```

At this point, the TALK light should be on. The IFC command can be sent by entering the following statement into the computer:

```
ABORTIO 7
```

After the RETURN key is pressed, the TALK indicator turns off, indicating that the instrument has gone into the talker idle state.

4.8.3 LLO (local lockout)

The LLO command is used to prevent local operation of the instrument. After the unit receives LLO, all its front panel controls except POWER are inoperative. In this state, pressing LOCAL will not restore control to the front panel.

Programming example — The LLO command is sent by entering the following statements:

```
REMOTE 716
LOCAL LOCKOUT 7
```

After the second statement is executed, the instrument's front panel controls are locked out, including the LOCAL key.

To restore front panel operation after asserting LLO, as in the following example, enter:

```
LOCAL 7
```

4.8.4 GTL (go to local) and local

The GTL command is used to take the instrument out of the remote state. Operation of the front panel keys will also be restored by GTL unless LLO is in effect. To cancel LLO, you must set REN false.

Programming example — Place the instrument in the remote state with the following statement:

```
REMOTE 716
```

Now send GTL with the following statement:

```
LOCAL 716
```

Note that the instrument goes into the local state, and that operation of the front panel keys has now been restored (assuming that LLO is not in effect).

4.8.5 DCL (device clear)

The DCL command may be used to clear the IEEE GPIB interface and return it to a known state. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously.

When the Model 2001 receives a DCL command, it will clear the Input Buffer and Output Queue, cancel deferred commands, and clear any command that prevents the processing of any other device command. A DCL will not affect instrument settings and stored data.

Programming example — Use the following statement to perform a DCL:

```
CLEAR 7
```

When the RETURN key is pressed, the instrument will perform the DCL.

4.8.6 SDC (selective device clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. However, since each device must be individually addressed, the SDC command provides a method to clear only selected instruments instead of clearing all instruments simultaneously, as is the case with DCL.

Programming example — Use the following statement to perform an SDC:

```
CLEAR 716
```

This sends the following IEEE-488 commands: UNT UNL LISTEN 16 SDC. When the statement is executed, the instrument performs the SDC.

4.8.7 GET (group execute trigger)

GET is a GPIB trigger that is used as an arm, scan and/or measure event to control operation. The Model 2001 will react to this trigger if it is the programmed control source. GET can also be used as the pre-trigger for the reading buffer. The control source is programmed from the SCPI :TRIGger subsystem (see paragraph 4.24).

With the instrument programmed and waiting for a GPIB trigger, the following programming statement will provide the GET:

```
TRIGGER 716
```

This sends IEEE-488 commands UNT UNL LISTEN 16 GET. When the ENTER key is pressed, the trigger event occurs. (The command TRIGGER 7 just sends GET. Any other listeners are triggered when the ENTER key is pressed.)

4.8.8 SPE, SPD (serial polling)

The serial polling sequence is used to obtain the Model 2001 serial poll byte. The serial poll byte contains important information about internal functions, as described in paragraph 4.6.9. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line. However, the serial polling sequence may be performed at any time to obtain the status byte from the Model 2001.

Programming example — The SPOLL statement automatically performs the serial poll sequence. To demonstrate serial polling, enter in the following statements into the computer:

```
S=SPOLL  (716)
PRINT "SPOLL BYTE =";S
```

After the first statement, the controller conducts the serial polling sequence. After the second statement is executed, the decimal value of the serial poll byte is displayed on the controller CRT.

4.9 Programming syntax

The following programming syntax information covers both common commands and SCPI commands. For information not covered here, refer to the documentation for the IEEE-488.2 standard and SCPI.

Command words

One or more command words make up the program message that is sent to the computer to perform one or more operations.

1. **Commands and command parameters:** Both common commands and SCPI commands may or may not use a parameter. Examples:

*SAV 0	Parameter (0) required.
*RST	No parameter used with this command.
:INITiate:CONTinuous <b>	Parameter (<b>) required.
:SYSTem:PRESet	No parameter used with this command.

Note that there must be a space between the command word and the parameter.

Brackets [ ]: Throughout this manual, you will find command words that are enclosed in brackets ([]). These brackets are simply used to denote an optional command word that does not need to be included in the program message. For example:

:INITiate[:IMMediate]

The brackets indicate that :IMMediate is implied (optional) and does not have to be used. Thus, the above command can be sent in one of two ways:

:INITiate or :INITiate:IMMediate

Notice that the optional command is used without the brackets. **Do not include the brackets when using an optional command word.**

Parameter types: Some of the more common parameter types used in this manual are explained as follows:

<b> Boolean: Used to enable or disable an instrument operation. 0 or OFF disables the operation, and 1 or ON enables the operation. Example:

:CURRent:AC:RANGe:AUTO ON Enable auto-ranging.

AC|DC Explicit: This is an example of two explicit parameters to choose from; AC or DC. Example:

:CURRent:AC:COUPling AC Select AC coupling

<name> Name parameter: Select a parameter name from a listed group. Example:

<name> = NEVer
= NEXt
= ALWays
= PRETrigger

:TRACe:FEED:CONTrol PRETrigger

<NRf> Numeric representation format: This parameter is a number that can be expressed as an integer (e.g., 8), a real number (e.g., 23.6) or an exponent (2.3E6). Example:

```
:SYSTem:KEY  16          "Press" NEXT key from over the bus.
```

<n> Numeric value: A numeric value parameter can consist of an NRf number or one of the following name parameters; DEFault, MINimum or MAXimum. When the DEFault parameter is used, the instrument will be programmed to the *RST default value. When the MINimum parameter is used, the instrument will be programmed to the lowest allowable value. When the MAXimum parameter is used, the instrument will be programmed to the largest allowable value. Examples:

```
:TRIGger:TIMer  0.1       Sets timer to 100msec.
:TRIGger:TIMer  DEFault   Sets timer to 1sec.
:TRIGger:TIMer  MINimum   Sets timer to 1msec.
:TRIGger:TIMer  MAXimum   Sets timer to 999999.999sec.
```

Angle brackets < >: In this manual, angle brackets (<>) are used to denote parameter type. **Do not** include the brackets in the program message. For example:

```
:SOURce:TTL2  <b>
```

The <b> indicates that a Boolean type parameter is required. Thus, to set digital input line #2 true, you must send the command with the ON or 1 parameter as follows:

```
:SOURce:TTL2  ON or :SOURce:TTL2  1
```

2. **Query commands:** This type of command requests (queries) the currently programmed status. It is identified by the question mark (?) at the end of the fundamental form of the command. Most commands have a query form. Examples:

```
*OPT?                Common query command.
:TRIGger:TIMer?      SCPI query command.
```

Most commands that require a numeric parameter (<n>) can also use the DEFault, MINimum, and MAXimum parameters for the query form. These query forms are used to determine the *RST default value, and the upper and lower limits for the fundamental command. Examples:

```
:TRIGger:TIMer?  DEFault   Queries the *RST default value.
:TRIGger:TIMer?  MINimum   Queries the lowest allowable value.
:TRIGger:TIMer?  MAXimum   Queries the largest allowable value.
```

3. **Case sensitivity:** Common commands and SCPI commands are not case sensitive. You can use upper or lower case, and any case combination. Examples:

```
*RST              = *rst
:SCAN?            = :scan?
:SYSTem:PRESet    = :system:preset
```

4. **Long-form and short-form versions:** A SCPI command word can be sent in its long-form or short-form version. The command subsystem tables in this section provide the commands in the long-form version. However, the short-form version is indicated by upper case characters. Examples:

:SYSTem:PRESet	Long-form
:SYST:PRES	Short-form
:SYSTem:PRES	Long and short-form combination

Note that each command word must be in long-form or short-form, and not something in between. For example, :SYSTe:PRESe is illegal and will generate an error. The command will not be executed.

There are no short-form versions for common commands.

Short-form rules: The following rules can be used to determine the short-form version of any SCPI command:

A. If the length of the command word is four letters or less, there is no short-form version. Examples:

:auto = :auto
:line = :line

B. The following rules apply to command words that exceed four letters:

a. If the fourth letter of the command word is a vowel, delete it and all the letters after it. Examples:

:immediate = :imm
:timer = :tim

Rule exception – The short-form version of the following command uses only the first two letters of the word:

:TCouple = :tc

b. If the fourth letter of the command word is a consonant, retain it but drop all the letters after it. Examples:

:output = :outp
:asynchronous = :asyn

C. If there is a question mark (?; query) or a non-optional number included in the command word, it must be included in the short-form version. Examples:

:delay? = :del?
:layer2 = :lay2

D. As previously explained, command words or characters that are enclosed in brackets ([]) are optional and need not be included in the program message. Example:

:STATus:OPERation[:EVENt]?

The brackets ([]) indicate that :EVENt is optional. Thus, either of the following two command program messages are valid:

:STATus:OPERation:EVENt? = :STATus:OPERation?

Notice that when using the optional word or character, the brackets ([]) are not included in the program message.

The complete short-form version of the above command is as follows:

:stat:oper?

Program messages

A program message is made up of one or more command words sent by the computer to the instrument. Each common command is simply a three letter acronym preceded by an asterisk (*). SCPI commands are categorized into subsystems and are structured as command paths. The following command paths are contained in the :STATus subsystem and are used to help explain how command words are structured to formulate program messages.

:STATus	Path (Root)
:OPERation	Path
:PTRansition <NRf>	Command and parameter
:NTRansition <NRf>	Command and parameter
:ENABle <NRf>	Command and parameter
:PRESet	Command

1. **Single command messages:** There are three levels to the above command structure. The first level is made up of the root command (:STATus) and serves as a path. The second level is made up of another path (:OPERation) and a command (:PRESet). The third path is made up of three commands for the :OPERation path. The four commands in this structure can be executed by sending four separate program messages as follows:

   :stat:oper:ptr <NRf>
   :stat:oper:ntr <NRf>
   :stat:oper:enab <NRf>
   :stat:pres

   In each of the above program messages, the path pointer starts at the root command (:stat) and moves down the command levels until the command is executed.

2. **Multiple command messages:** Multiple commands can be sent in the same program message as long as they are separated by semicolons (;). Example showing two commands in one program message:

   :stat:pres; :stat:oper:enab <NRf>

   When the above message is sent, the first command word is recognized as the root command (:stat). When the next colon is detected, the path pointer moves down to the next command level and executes the command. When the path pointer sees the colon after the semicolon (;), it resets back to the root level and starts over.

   Commands that are on the same command level can be executed without having to retype the entire command path. Example:

   :stat:oper:enab <NRf>; ptr <NRf>; ntr <NRf>

   After the first command (:enab) is executed, the path point is at the third command level in the structure. Since :ptr and :ntr are also on the third level, they can be typed in without repeating the entire path name. Notice that the leading colon for :ptr and :ntr are not included in the program message. If a colon were included, the path pointer would reset to the root level and expect a root command. Since neither :ptr nor :ntr are root commands, an error would occur.

3. **Command path rules:**

   A. Each new program message must begin with the root command, unless it is optional (e.g., [:SENSe]). If the root is optional, simply treat a command word on the next level as the root.

   B. The colon (:) at the beginning of a program message is optional and need not be used. Example:

      :stat:pres = stat:pres

   C. When the path pointer detects a colon (:) it will move down to the next command level. An exception is when the path pointer detects a semicolon (;), which is used to separate commands within the program message (see next rule).

   D. When the path pointer detects a colon (:) that immediately follows a semicolon (;), it resets back to the root level.

   E. The path pointer can only move down. It cannot be moved up a level. Executing a command at a higher level requires that you start over at the root command.

4. **Using common commands and SCPI commands in same message:** Both common commands and SCPI commands can be used in the same message as long as they are separated by semicolons (;). A common command can be executed at any command level and will not affect the path pointer. Example:

   :stat:oper:enab <NRf>; ptr <NRf>; *ESE <NRf>; ntr <NRf>

5. **Program Message Terminator (PMT):** Each program message must be terminated with an LF (line feed), EOI (end or identify) or an LF + EOI. The bus will hang if your computer does not provide this termination. The following example shows how a multiple command program message must be terminated:

   :rout:open all; scan (@1:5) <PMT>

6. Command execution rules:

   A. Commands are executed in the order that they are presented in the program message.

   B. An invalid command will generate an error and, of course, not be executed.

   C. Valid commands that precede an invalid command in a multiple command program message will be executed.

   D. Valid commands that follow an invalid command in a multiple command program message will be ignored. Example:

      :rout:open all; harve; scan?

      :open all will execute. Harve is an invalid command and will generate an error. The scan query will be ignored.

Response messages

A response message is the message sent by the instrument to the computer in response to a query command program message.

1. **Sending a response message:** After sending a query command, the response message is placed in the Output Queue. When the Model 2001 is then addressed to talk, the response message is sent from the Output Queue to the computer. The following example in HP BASIC 4.0 demonstrates this process:

```
10  OUTPUT 716; ":rout:scan?"     ! Send query command.
20  ENTER 716; A$                 ! Address Model 2001 to talk.
30  PRINT A$                      ! Display response message on CRT.
40  END
```

   There are two special query commands that are used to read the Error Queue. As error and status messages occur they are stored in the Error Queue. This queue is a first-in first-out (FIFO) register. Either of the following two SCPI commands can be used to read the Error Queue:

   :STATus:QUEue?
   :SYSTem:ERRor?

   After sending either of the above commands, the oldest message in the Error Queue will be moved to the Output Queue. When the Model 2001 is then addressed to talk (as explained above), the response message will be sent to the computer.

2. **Multiple response messages:** If you send more than one query command in the same program message (see Multiple command messages), the multiple response message for all the queries will be sent to the computer when the Model 2001 is addressed to talk. The responses are sent in the order that the query commands were sent and will be separated by semicolons (;). Items within the same query are separated by commas (,). The following example shows the response message for a program message that contains four single item query commands:

   0; 1; 1; 0

3. **Response Message Terminator (RMT):** Each response message is terminated with an LF (line feed) and EOI (end or identify). The following example shows how a multiple response message is terminated:

   0; 1; 1; 0 <RMT>

Message exchange protocol

The message exchange protocol can be summarized by the two following rules:

Rule 1. You must always tell the Model 2001 what to send to the computer.

The following two steps must always be performed, in this order, to send information from the instrument to the computer:

1. Send the appropriate query command(s) in a program message.
2. Address the Model 2001 to talk.

Rule 2. The complete response message must be received by the computer before another program message can be sent to the Model 2001.

4.0 Common commands

Common commands are device commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Table 4-4 summarizes the common commands used by the Model 2001. Commands are presented in alphabetical order. The following detailed descriptions include programming examples using HP BASIC 4.0.

Table 4-4
IEEE-488.2 common commands and queries

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers, and Error Queue.
*ESE <NRf>	Event Enable command	Sets the contents of the Standard Event Enable Register.
*ESE?	Event Enable query	Request the programmed value of the Standard Event Enable Register.
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII "1" into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Returns an ID code that indicates which memory option is installed and whether or not the optional scanner card is installed.
*RCL <NRf>	Recall command	Returns the Model 2001 to the setup configuration stored in the designated memory location.
*RST	Reset command	Returns the Model 2001 to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.
*SRE?	Service request enable query	The Model 2001 returns the value of the Service Request Enable Register.
*STB?	Read status byte query	Returns the value of the Status Byte Register.
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.
*TST?	Self-test query	When this query is sent, the Model 2001 will perform a checksum test on ROM and return the results.
*WAI	Wait-to-continue command	Wait until all previous commands are executed.

4.0.1 *CLS — clear status

Purpose To clear status registers and error queue.

Format *CLS

Description The *CLS command is used to clear (reset to 0) the bits of the following registers in the Model 2001:

Standard Event Status Register
Operation Event Status Register
Error Queue
Trigger Event Status Register
Sequence Event Status Register
Arm Event Status Register
Measurement Event Status Register
Questionable Event Status Register

This command also forces the instrument into the operation complete command idle state and operation complete query idle state.

Programming Example

```
OUTPUT 716; "*CLS"          ! Clear registers and Error Queue.
```

4.0.2 *ESE — event enable

Purpose To set the contents of the Standard Event Enable Register.

Format *ESE <NRf>

Parameters

<NRf>	= 0	Clear (reset) register
	= 1	Set OPC (B0) of enable register
	= 4	Set QYE (B2) of enable register
	= 8	Set DDE (B3) of enable register
	= 16	Set EXE (B4) of enable register
	= 32	Set CME (B5) of enable register
	= 64	Set URQ (B6) of enable register
	= 128	Set PON (B7) of enable register

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description The *ESE command is used to set the contents of the Standard Event Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of the bits in the register.

This register is used as a mask for the Standard Event Status Register. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status

Byte Register. Conversely, when a standard event is unmasked (enabled), the occurrence of that event will set the ESB bit. For information on the Standard Event Status Register and descriptions of the standard event bits, see paragraph 4.10.4. The Status Byte Register is described in paragraph 4.6.9.

A cleared bit (bit set to "0") in the enable register will prevent (mask) the ESB bit in the Status Byte Register from setting when the corresponding standard event occurs. A set bit (bit set to "1") in the enable register will allow (enable) the ESB bit to set when the corresponding standard event occurs. For details on the status register structure, refer to paragraph 4.6.

The Standard Event Enable Register is shown in Figure 4-15. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to be set is the value that is sent with the *ESE command. For example, to set the CME and QYE bits of the Standard Event Enable Register, send the following command:

*ESE 36

where; CME (bit B5) = Decimal 32
QYE (bit B2) = Decimal 4
parameter = 36

If a command error (CME) occurs, bit B5 of the Standard Event Status Register will set. If a query error (QYE) occurs, bit B2 of the Standard Event Status Register will set. Since both of these events are unmasked (enabled), the occurrence of any one of them will cause the ESB bit in the Status Byte Register to set.

The contents of the Standard Event Status Event Register can be read by using the *ESE? query command (see next paragraph).

Programming Example

```
OUTPUT 716; "*ESE 24"        ! Set bits B3 (DDE) and B4 (EXE) of the Standard Event
                               Enable Register.
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device-dependent Error
QYE = Query Error
OPC = Operation Complete

Figure 4-15
Standard Event Enable Register

4.0.3 *ESE? — event enable query

Purpose To read the contents of the Standard Event Enable Register.

Format *ESE?

Description This command is used to acquire the value (in decimal) of the Standard Event Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *ESE? query command is sent, the decimal value is placed in the Output Queue. When the Model 2001 is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. For this binary value, bits B4 and B5 of the Standard Event Enable Register are set. For information on the Standard Event Enable Register, refer to paragraph 4.6.

The *ESE? query command does not clear the Standard Event Enable Register.

Programming Example

```
10  OUTPUT 716; "*ESE?"      ! Send query command
20  ENTER 716; A$            ! Address 2001 to talk
30  PRINT A$                 ! Display value of register contents
40  END
```

4.0.4 *ESR? — event status register query

Purpose To read the contents of the Standard Event Status Register and clear it.

Format *ESR?

Defaults

Power-up	Clears register
*CLS	Clears register
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description This command is used to acquire the value (in decimal) of the Standard Event Status Register (see Figure 4-16). The binary equivalent of the returned decimal value determines which bits in the register are set. When the *ESR? command is sent, the decimal value is placed in the Output Queue and the Standard Event Status Register is cleared. When the Model 2001 is addressed to talk, the value in the Output Queue is sent to the computer.

A set bit in this register indicates that a particular event has occurred. For example, for an acquired decimal value of 48, the binary equivalent is 00110000. For this binary value, bits B4 and B5 of the Standard Event Status Register are set. These set bits indicate that a device-dependent error and command error have occurred.

The bits of the Standard Event Status Register are described as follows:

Bit B0, Operation Complete (OPC) — Set bit indicates that all pending selected device operations are completed and the Model 2001 is ready to accept new commands. This bit will only set in response to the *OPC? query command (see paragraph 4.10.7).

Bit B1 — Not Used.

Bit B2, Query Error (QYE) — Set bit indicates that you attempted to read data from an empty Output Queue.

Bit B3, Device-dependent Error (DDE) — Set bit indicates that an instrument operation did not execute properly due to some internal condition.

Bit B4, Execution Error (EXE) — Set bit indicates that the Model 2001 detected an error while trying to execute a command.

Bit B5, Command Error (CME) — Set bit indicates that a command error has occurred. Command errors include:

1. IEEE-488.2 syntax error: Model 2001 received a message that does not follow the defined syntax of the IEEE-488.2 standard.
2. Semantic error: Model 2001 received a command that was misspelled, or received an optional IEEE-488.2 command that is not implemented.
3. The instrument received a Group Execute Trigger (GET) inside a program message.

Bit B6, User Request (URQ) — Set bit indicates that the LOCAL key on the Model 2001 front panel was pressed.

Bit B7, Power On (PON) — Set bit indicates that the Model 2001 has been turned off and turned back on since the last time this register has been read.

Programming Example

```
10 OUTPUT 716; "*ESE?"      ! Request register value
20 ENTER 716; A$            ! Address Model 2001 to talk
30 PRINT A$                 ! Display value
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device-dependent Error
QYE = Query Error
OPC = Operation Complete

Figure 4-16
Standard Event Status Register

4.0.5 *IDN? — identification query

Purpose To read the identification code of the Model 2001.

Format *IDN?

Description The *IDN? query command places the identification code of the Model 2001 in the Output Queue. When the Model 2001 is addressed to talk, the identification code will be sent to the computer.

The identification code includes the manufacturer, model number, serial number, and firmware revision levels, and is sent in the following format:

KEITHLEY INSTRUMENTS INC., MODEL 2001, xxxxxxx, yyyyy/zzzzz

where; xxxxxxx is the serial number
yyyyy/zzzzz is the firmware revision levels of the digital board ROM and display board ROM.

Programming Example

```
10  OUTPUT 716; "*IDN?"        ! Request 2001 ID data
20  ENTER 716; A$              ! Address 2001 to talk
30  PRINT A$                   ! Display identification code
```

4.0.6 *OPC — operation complete

Purpose To set the Operation Complete bit in the Standard Event Status Register after all pending commands are complete.

Format *OPC

Description After the *OPC command is sent, the Operation Complete bit (bit B0) of the Standard Event Status Register will set immediately after the last pending command is completed. If the corresponding bit (Bit B0) in the Standard Event Enable Register and Bit 5 (Event Summary Bit) of the Service Request Enable Register are set, the RQS/MSS (Request for Service/Master Summary Status) bit in the Status Byte Register will set.

When used with the immediate initiation command (:INITiate), the OPC bit in the Standard Event Status Register will not set until the Model 2001 goes back into the idle state. The :INIT command operation is not considered finished until the Model 2001 goes back into the idle state. See paragraph 4.10.17 (*WAI) for more information on command execution.

Programming Example Two programs are used to demonstrate how *OPC functions. The first program sends the *OPC command after the :INITiate command and verifies that the OPC bit in the Standard Event Status Register does not set while the instrument continues to make measurements (not in idle). The second program returns the Model 2001 to the idle state and verifies that the OPC bit did set.

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":init:cont  off; :abort"
30  OUTPUT 716; ":init; *opc"
40  OUTPUT 716; "*esr?"
50  ENTER 716; A$
```

```
60  PRINT A$
70  END

100 OUTPUT 716; ":abort"
110 OUTPUT 716; "*esr?"
120 ENTER 716; A$
130 PRINT A$
140 OUTPUT 716; ":syst:pres"
150 END
```

Line 10	Resets the Model 2001 to default operating conditions.
Line 20	Disables continuous initiation and aborts operation. This places the Model 2001 in the idle state.
Line 30	Performs an immediate initiation to restart the measurement process, and then sends the *OPC command.
Lines 40 thru 60	Reads the Standard Event Status Register. The returned value of 0 denotes that the bit (bit 0) is not set indicating that the :INITiate operation is not complete.
Line 100	Aborts 2001 operation by placing it in the idle state.
Lines 110 thru 130	Reads the Standard Event Status Register. The returned value of 1 denotes that the bit (bit 1) is set indicating that the :INITiate operation is now complete.
Line 140	Returns the instrument to the default operating configuration.

4.0.7 *OPC? — operation complete query

Purpose Place a "1" in the Output Queue after all pending operations are completed.

Format *OPC?

Description When this common command is sent, an ASCII "1" will be placed in the Output Queue after the last pending operation is completed. When the Model 2001 is then addressed to talk, the "1" in the Output Queue will be sent to the computer.

The "1" in the Output Queue will set the MAV (Message Available) bit (B4) of the Status Byte Register. If the corresponding bit (B4) in the Service Request Enable Register is set, the RQS/MSS (Request for Service/Master Summary Status) bit in the Status Byte Register will set.

When used with the Initiate Immediately command (:INITiate), a "1" will not be placed into the Output Queue until the Model 2001 goes back into the idle state. The :INIT command operation is not considered finished until the Model 2001 goes back into the idle state. See paragraph 4.10.17 (*WAI) for more information on command execution.

The execution of OPC? is not completed until it has placed the "1" in the Output Queue. For example, ":INITiate:CONTinuous ON; *OPC?" will lock up the instrument and will require a device clear (DCL or SDC) before it will accept any more commands.

Programming Example

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":init:cont  off; :abort"
30  OUTPUT 716; ":arm:coun  1"
40  OUTPUT 716; ":trig:coun  5; sour  tim"
50  OUTPUT 716; ":init; *opc?"
```

```
60  ENTER 716; A$
70  PRINT A$
80  OUTPUT 716; ":syst:pres"
90  END
```

Line 10 Resets the Model 2001 to default operating conditions.

Line 20 Disables continuous initiation and aborts operation. This places the Model 2001 in the idle state.

Lines 30 and 40 Configures the instrument to perform five measurements.

Line 50 Performs an immediate initiation (:INITiate) to restart the measurement process and sends the *OPC? command.

After all five measurements are performed and the instrument has returned to the idle state, an ASCII "1" will be placed in the Output Queue.

Line 60 Addresses the Model 2001 to talk. This sends the "1" from the Output Queue to the computer.

Line 70 Displays the "1" on the CRT.

Line 80 Returns the instrument to the default operating configuration.

4.0.8 *OPT? — option identification query

Purpose To determine which options are installed in the Model 2001.

Format *OPT?

Description The *OPT? query command places the option identification code in the Output Queue. When the Model 2001 is addressed to talk, the code is sent from the Output Queue to the computer. The code is made up of two comma separated fields. The first field indicates the presence or absence of extra memory.

0	No extra memory (8k bytes volatile)
MEM1	Memory Option 1 (32k bytes non-volatile)
MEM2	Memory Option 2 (128k bytes non-volatile)

The second field indicates the presence or absence of the Model 2001-SCAN scanner card.

0	No scanner card installed
2001-SCAN	Model 2001-SCAN installed

Example: The following response message indicates that Memory Option 2 and the scanner card are installed:

MEM2, 2001-SCAN

Programming Example

```
10  OUTPUT 716; "OPT?"      ! Request option ID code
20  ENTER 716; A$           ! Address 2001 to talk
30  PRINT A$                ! Display option ID code
40  END
```

4.0.9 *RCL — recall

Purpose To return the Model 2001 to a setup configuration previously stored in memory.

Format *RCL <NRf>

No extended memory	Model 2001-MEM1 installed	Model 2001-MEM2 installed
<NRf> = 0	<NRf> = 0 to 4	<NRf> = 0 to 9

Description The *RCL command is used to return the Model 2001 to a setup configuration stored at a memory location. The *SAV command is used to store a setup configuration at a memory location (see paragraph 4.10.11).

If the Model 2001 does not have any extended memory installed, only one setup configuration can be saved and recalled. In this situation, memory location "0" is the only valid parameter for the *RCL command. If the Model 2001 has the Model 2001-MEM1 memory element installed, up to five setup configurations can be saved and recalled. In this situation, memory locations "0" through "4" are valid parameters. If the Model 2001 has the Model 2001-MEM2 memory element installed, up to 10 setup configurations can be saved and recalled. Memory locations "0" through "9" are then valid parameters.

The Model 2001 is shipped from the factory with :SYSTem:PRESet defaults loaded into the available setup memories (see Appendix B). If a recall error occurs, the setup memories will set to the :SYSTem:PRESet values.

Programming Example

```
OUTPUT 716; "*RCL  0"          ! Recall setup stored at memory location 0.
```

4.0.10 *RST — reset

Purpose To reset the Model 2001.

Format *RST

Description When the *RST command is sent, the Model 2001 performs the following operations:

1. Returns the Model 2001 to the *RST default conditions (see Appendix B).
2. Cancels all pending commands.
3. Cancels response to any previously received *OPC and *OPC? commands.

Instrument states not affected by *RST are denoted in Appendix B.

Programming Example

```
OUTPUT 716; "*RST"             ! Return 2001 to the *RST defaults
```

4.0.11 *SAV — save

Purpose To save the current setup configuration in memory.

Format *SAV <NRf>

No extended memory	Model 2001-MEM1 installed	Model 2001-MEM2 installed
<NRf> = 0	<NRf> = 0 to 4	<NRf> = 0 to 9

Description The *SAV command is used to save the current instrument setup configuration in memory for later recall. Any control affected by *RST (see Appendix B) can be saved by the *SAV command. The *RCL command is used to restore the instrument to a saved setup configuration (see paragraph 4.10.9).

If the Model 2001 does not have any extended memory installed, only one setup configuration can be saved and recalled. In this situation, memory location "0" is the only valid parameter for the *SAV command. If the Model 2001 has the Model 2001-MEM1 memory element installed, up to five setup configurations can be saved and recalled. In this situation, memory locations "0" through "4" are valid parameters. If the Model 2001 has the Model 2001-MEM2 memory element installed, up to 10 setup configurations can be saved and recalled. Memory locations "0" through "9" are then valid parameters.

Programming Example

```
OUTPUT 716; "*SAV  0"          ! Store setup at memory location 0.
```

4.0.12 *SRE — service request enable

Description To set the contents of the Service Request Enable Register.

Format *SRE <NRf>

Parameters

<NRf> = 0 Clears enable register
= 1 Set MSB bit (Bit 0)
= 4 Set EAV bit (Bit 2)
= 8 Set QSB bit (Bit 3)
= 16 Set MAV bit (Bit 4)
= 32 Set ESB bit (Bit 5)
= 128 Set OSB bit (Bit 7)

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description The *SRE command is used to set the contents of the Service Request Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the register.

This enable register is used along with the Status Byte Register to generate service requests (SRQ). With a bit in the Service Request Enable Register set, an SRQ will occur when the corresponding bit in the Status Byte Register is set by an appropriate event. For details on register structure, refer to paragraph 4.6.

The Service Request Enable Register is shown in Figure 4-17. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to set is the value that is sent with the *SRE command. For example, to set the ESB and MAV bits of the Service Request Enable Register, send the following command:

*SRE 34

where; ESB (bit B5) = Decimal 32
MAV (bit B4) = Decimal 16
parameter = 48

The contents of the Service Request Enable Register can be read using the *SRE? query command (see next paragraph).

Programming Example

```
OUTPUT 716; "*SRE 32"          ! Set ESB bit
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	—	ESB	MA	QSB	EAV	—	MSB
Decimal Weighting	128 (2^7)	—	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	—	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Enable Service Request Event
0 = Disable (Mask) Service Request Event

Events : OSB = Operation Summary Bit
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available
MSB = Measurement Summary Bit

Figure 4-17
Service Request Enable Register

4.0.13 *SRE? — service request enable query

Purpose To read the contents of the Service Request Enable Register.

Format *SRE?

Description The *SRE? command is used to acquire the value (in decimal) of the Service Request Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *SRE? query command is sent, the decimal value is placed in the Output Queue. When the Model 2001 is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 17, the binary equivalent is 00010001. This binary value indicates that Bits 4 and 0 of the Service Request Enable Register are set (see previous paragraph).

Programming Example

```
10  OUTPUT 716; "*SRE?"     ! Request contents of SRER
20  ENTER 716; A$           ! Address 2001 to talk
30  PRINT A$                ! Display value register
```

4.0.14 *STB? — status byte query

Purpose To read the contents of the Status Byte Register.

Format *STB?

Description The *STB? query command is used to acquire the value (in decimal) of the Status Byte Register. The Status Byte Register is shown in Figure 4-18. The binary equivalent of the decimal value determines which bits in the register are set. The set bits in this register define the operating status of the Model 2001.

When the *STB? query command is sent, the decimal value is placed in the Output Queue. When the Model 2001 is addressed to talk, the value is sent from the Output Queue to the computer.

All bits, except Bit 6, in this register are set by other event registers and queues. Bit 6 sets when one or more enabled conditions occur.

The *STB? query command does not clear the status byte register. This register can only be cleared by clearing the related registers and queues. Register and queue structure are explained in paragraph 4.6.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. This binary value indicates that Bits 4 and 5 of the Status Byte Register are set.

The bits of the Status Byte Register are described as follows:

Bit 0, Measurement Status (MSB) — Set bit indicates that a measurement event has occurred. The event can be identified by reading the Measurement Event Status Register using the :STATus:MEASurement? command (see paragraph 4.21 for details).

Bit 1 — Not used.

Bit 2, Error Available (EAV) — Set bit indicates that an error or status message is present in the Error Queue. The message can be read using one of the following SCPI commands:

:SYSTem:ERRor?
:STATus:QUEue?

See paragraphs 4.21 and 4.22 for details.

Bit 3, Questionable Summary Bit (QSB) — Set bit indicates that a calibration error has occurred.

Bit 4, Message Available (MAV) — Set bit indicates that a message is present in the Output Queue. The message is sent to the computer when the Model 2001 is addressed to talk.

Bit 5, Event Summary Bit (ESB) — Set bit indicates that a standard event has occurred. The event can be identified by reading the Standard Event Status Register using the *ESE? query command (see paragraph 4.10.3).

Bit 6, Master Summary Status (MSS) / Request Service (RQS) — Set bit indicates that one or more enabled Status Byte conditions have occurred. The MSS bit can be read using the STB? query command, or the occurrence of a service request (RQS bit set) can be detected by performing a Serial Poll.

Bit 7, Operation Summary Bit (OSB) — Set bit indicates that an enabled operation event has occurred. The event can be identified by reading the Operation Event Status Register using the :STATus:OPERation? query command (see paragraph 4.21 for details).

Programming Example

```
10  OUTPUT 716; "*SRE?"      ! Request contents of register
20  ENTER 716; A$            ! Address 2001 to talk
30  PRINT A$                 ! Display value of register
40  END
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	MSS, RQS	ESB	MA	QSB	EAV	—	MSB
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : OSB = Operation Summary Bit
MSS = Master Summary Status
RQS = Request Service
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available
MSB = Measurement Summary Bit

Figure 4-18
Status Byte Register

4.0.15 *TRG — trigger

Purpose To issue a GPIB trigger to the Model 2001.

Format *TRG

Description The *TRG command is used to issue a GPIB trigger to the Model 2001. It has the same effect as a group execute trigger (GET).

The *TRG command is used as an arm, scan and/or measure event to control operation. The Model 2001 will react to this trigger if GPIB is the programmed control source. The control source is programmed from the SCPI :TRIGger subsystem (see paragraph 4.24).

*TRG can also be used as the pre-trigger for buffer operation.

Programming Example

```
OUTPUT 716; "*TRG"          ! Trigger 2001
```

4.0.16 *TST? — self-test query

Purpose To run the self-tests and acquire the results.

Format *TST?

Description The *TST? query command is used to perform a checksum test on ROM and places the coded result (0 or 1) in the Output Queue. When the Model 2001 is addressed to talk, the coded result is sent from the Output Queue to the computer.

A returned value of zero (0) indicates that the test passed, and a value of one (1) indicates that the test has failed.

Programming Example

```
10  OUTPUT 716; "*TST?"      ! Run and request test result
20  ENTER 716; A$            ! Address 2001 to talk
30  PRINT A$                 ! Display coded result
```

4.0.17 *WAI — wait-to-continue

Purpose To prevent the execution of further commands until all previous commands are completed.

Format *WAI

Description There are two types of device commands; Sequential commands and Overlapped commands. A Sequential command is a command whose operations are allowed to finish before the next command is executed. An Overlapped command is a command that allows the execution of subsequent commands while device operations of the Overlapped command are still in progress. The *WAI command is used to hold off the execution of subsequent commands until the device operations of all previous Overlapped commands are finished. The *WAI command is not needed for Sequential commands.

There are two Overlapped commands in the Model 2001; :INITiate and *TRG.

The :INITiate command takes the Model 2001 out of the idle state. The device operations of :INITiate are not considered complete until the Model 2001 goes back into the idle state. By sending the *WAI command after the :INITiate command, all subsequent commands will not execute until the Model 2001 goes back into idle.

The *TRG command issues a bus trigger which could be used to provide the arm, scan and measure events for the Trigger Model. By sending the *WAI command after the *TRG command, subsequent commands will not be executed until the pointer for the Trigger Model has finished moving in response to *TRG and has settled at its next state.

Programming Example

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":init:cont  off; :abort"
30  OUTPUT 716; ":arm:coun  1"
40  OUTPUT 716; ":trig:coun  5; sour  tim"
50  OUTPUT 716; ":init; *wai"
60  OUTPUT 716; ":data?"
70  ENTER 716; A$
80  PRINT A$
90  OUTPUT 716; ":syst:pres"
100 END
```

Line 10 Resets the Model 2001 to default operating conditions.

Line 20 Disables continuous initiation and aborts operation. This places the Model 2001 in the idle state.

Lines 30 and 40 Configures the instrument to perform five measurements.

Line 50 Performs an immediate initiation (:INITiate) to restart the measurement process and sends the *WAI? command.

Subsequent commands will not execute until all five measurements are performed and the instrument has returned to the idle state.

Line 60 Query a reading.

Line 70 Addresses the Model 2001 to talk. This sends the reading from the Output Queue to the computer.

Line 80 Displays the reading on the CRT.

Line 90 Returns the instrument to the default operating configuration.

4.11 Signal oriented measurement commands

The signal oriented command group is used to acquire readings using a set of high-level instructions to control the measurement process. These commands are summarized in Table 4-5.

Table 4-5
Signal oriented measurement command summary

Command	Description
:FETCh?	Requests the latest reading (SCPI) or a fresh reading (FRESh).
:CONFigure:<function>	Places the 2001 in a "one-shot" measurement mode for the specified function.
:READ?	Performs an :ABORt, :INITiate, and a :FETCh?.
:MEASure[:<function>]?	Performs an :ABORt, :CONFigure:<function>, and a :READ?.

:FETCh?

Format :fetc?

Description This query command is used to request a post-processed reading. After sending this command and addressing the Model 2001 to talk, a reading will be sent to the computer. This command does not affect the instrument setup.

The type of reading (latest or fresh) that is requested depends on which fetch format is selected; SCPI or FRESh.

With the SCPI fetch format selected, :FETCh? simply requests the last available reading. Note that this command can repeatedly return the same reading. In the absence of a new reading, :FETCh? will simply return the old reading.

With the FRESh fetch format selected, :FETCh? is used to return a new (fresh) reading. In this format, you cannot use :FETCh? to return the same reading more than once. If :FETCh? is sent again, it will wait until a new reading is triggered and available. In this format, :FETCh? operates the same as the [:SENSe[1]]:DATA:FRESh? command.

At power-on, the fetch format is set to FRESh. The fetch format can be changed using the :SYSTem:FETch:FORMat command. Note that the fetch format is not affected by *RST or :SYSTem:PRESet.

Programming example

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":fetch?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Selects the :SYSTem:PRESet default conditions.
Line 20 Reads the latest measurement.
Line 30 Addresses the Model 2001 to talk.
Line 40 Displays the reading on the computer CRT.

:CONFigure:<function>

where; <function>	= VOLTage[:DC]	DCV function
	= CURRent[:DC]	DCI function
	= VOLTage:AC	ACV function
	= CURRent:AC	ACI function
	= RESistance	Ω2 function
	= FRESistance	Ω4 function
	= TEMPerature	TEMP function
	= FREQuency	FREQ function
	= VOLTage:FREQuency	FREQ function (voltage input)
	= CURRent:FREQuency	FREQ function (current input)

Formats

:conf:volt[:dc]
:conf:curr[:dc]
:conf:volt:ac
:conf:curr:ac
:conf:res
:conf:fres
:conf:temp
:conf:freq
:conf:volt:freq
:conf:curr:freq

Query

:CONFigure?	Query the selected function
Short-form format:	:conf?
Response message:	CURR:DC, VOLT:AC, CURR:AC, VOLT:DC, RES, FRES, TEMP, FREQ, VOLT:FREQ or CURR:FREQ

Description

This command is used to configure the instrument for subsequent measurements on the specified function. Basically, this command places the instrument in a "one-shot" measurement mode. The :READ? command can then be used to trigger a measurement and acquire a reading (see :READ?).

Note that there are three <function> versions to configure frequency; FREQuency, VOLTage:FREQuency and CURRent:FREQuency. When FREQuency is sent, the *RST input source is selected (voltage). When :VOLTage:FREQuency is sent, voltage input is selected. When CURRent:FREQuency is sent, current input is selected.

When this command is sent, the Model 2001 will be configured as follows:

- The function specified by this command is selected.
- All controls related to the selected function are defaulted to the *RST values.
- Continuous initiation is disabled (:INITiate:CONTinuous OFF).
- The control sources in all three layers of the Trigger Model are set to Immediate.
- The count values in all three layers of the Trigger Model are set to one (1).
- The delay in all three layers of the Trigger Model are set to zero (0).
- The Model 2001 is placed in the idle state.

- All math calculations are disabled.
- Buffer operation is disabled. A storage operation currently in process will be aborted.
- Auto-zero controls are set to the *RST default values.
- The acquisition method is set to normal.
- All operations associated with switching cards (scanning) are disabled.

This command is automatically asserted when the :MEASure? command is sent.

Programming example

```
OUTPUT 716; ":conf:volt:dc"        ! Perform :CONFigure operations.
```

:READ?

Format

:read?

Description

This command is typically used to acquire a post-processed reading after the instrument has been configured by the :CONFigure command. The :CONFigure command places the instrument in a "one-shot" measurement mode. Every time the :READ? command is then sent, a measurement conversion will occur and the reading will be acquired.

When this command is sent, the following commands will be executed in the order that they are presented:

:ABORt
:INITiate
:FETCh?

When :ABORt is executed, the instrument will go into the idle state if continuous initiation is disabled. Otherwise, operation will re-start at the beginning of the Trigger Model.

If the instrument is in the idle state, :INITiate will take the instrument out of the idle state. If continuous initiation is enabled (:INITiate:CONTinuous ON), then the :INITiate command will generate an error and ignore the command.

The :FETCh? command will then simply acquire a "fresh" post-processed reading. See :FETch? for details. Note that an "Init ignored" error will not cancel the execution of the :FETCh? command.

Programming example

```
10  OUTPUT 716; ":conf:volt[:dc]"
20  OUTPUT 716; ":read?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Places Model 2001 in "one-shot" DCV function.
Line 20 Performs the :READ? operations.
Line 30 Addresses the Model 2001 to talk.
Line 40 Displays the reading on the CRT.

:MEASure[:<function>]?

The brackets enclosing :<function> indicate that a measurement function does not need to be specified. When not used, the currently selected function will be used for the :MEASure? operations.

where; <function>	= VOLTage[:DC]	DCV function
	= CURRent[:DC]	DCI function
	= VOLTage:AC	ACV function
	= CURRent:AC	ACI function
	= RESistance	Ω2 function
	= FRESistance	Ω4 function
	= TEMPerature	TEMP function
	= FREQuency	FREQ function
	= VOLTage:FREQuency	FREQ function (voltage input)
	= CURRent:FREQuency	FREQ function (current input)

Formats

```
:meas?
:meas:volt[:dc]?
:meas:curr[:dc]?
:meas:volt:ac?
:meas:curr:ac?
:meas:res?
:meas:fres?
:meas:temp?
:meas:freq?
:meas:volt:freq?
:meas:curr:freq?
```

Description

This command combines all of the other signal oriented measurement commands to perform a "one-shot" measurement and acquire the reading.

When this command is sent, the following commands are executed in the order that they are presented:

:ABORt :CONFigure:<function> :READ?

When :ABORt is executed, the instrument will go into the idle state if continuous initiation is disabled. Otherwise, operation will re-start at the beginning of the Trigger Model.

When :CONFigure is executed, the instrument will go into a "one-shot" measurement mode. See :CONFigure for details.

When :READ? is executed, its operations will then be performed. In general, another :ABORt will be performed, then an :INITiate and finally a FETCh? to acquire the reading. See :READ? for details.

Programming example

```
10  OUTPUT 716; ":meas?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Performs :MEASure? operations.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the reading on the CRT.

4.12 SCPI command subsystems

SCPI commands are categorized into subsystems and are presented in the following alphabetical order:

4.13 Calculate subsystems — Covers the commands for the three Calculate subsystems. :CALCulate1 is used to configure and control the "mX+B" and "PERCENT" math operations. :CALCulate2 is used to manipulate readings stored in the buffer, and :CALCulate3 is used to configure and control the limit tests.

4.14 :CALibrate subsystem — Provides a table that summarizes the commands used to calibrate the Model 2001. Actual calibration procedures are contained in the Model 2001 Calibration Manual.

4.15 :DISPlay subsystem — Explains the commands that are used to control display readings and messages for the top and bottom portions of the display.

4.16 :FORMat subsystem — Covers the commands used to select the data format for transferring instrument readings over the bus.

4.17 :OUTPut subsystem — Covers the commands used to select the polarity for the digital output lines.

4.18 :ROUTe subsystem — Covers the commands that are used to control switching.

4.19 Sense subsystems — Explains the commands of the two Sense subsystems. :SENSe1 is used to configure and control the measurement functions of the Model 2001. :SENSe2 is used to read the digital input port.

4.20 :SOURce subsystem — Explains the commands used to control the digital output port.

4.21 :STATus subsystem — Covers the commands used to configure and control the status registers.

4.22 :SYSTem subsystem — Covers miscellaneous commands not covered by the other subsystems.

4.23 :TRACe subsystem — Explains the commands used to control the reading buffer.

4.24 Trigger subsystem — Covers the commands used to configure the Trigger Model.

4.25 :UNIT subsystem — Explains the commands used to select measurement units.

4.13 Calculate subsystems

The commands in this subsystem are used to configure and control the three Calculate subsystems and are summarized in Table 4-6.

Table 4-6
Calculate command summary

Command	Description	Reference
:CALCulate[1]	Subsystem to control CALC 1:	4.13.1
:FORMat <name>	Select math format: MXB, PERCent, PDEViation, NONE.	
:FORMat?	Query math format.	
:KMATh	Path to configure math calculations:	
:MMFactor <NRf>	Specify "m" for mX+b (-9.99e35 to +9.99e20).	
:MMFactor?	Query "m" factor.	
:MBFactor <NRf>	Specify "b" for mX+b (-9.99e35 to +9.99e30).	
:MBFactor?	Query "b" factor.	
:PERCent <NRf>	Set PERCENT value (-2.0e9 to +2.0e9).	
:PERCent?	Query PERCENT.	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.	
:STATe?	Query state of math function.	
:DATA?	Read math result of CALC 1.	
:IMMediate	Recalculate input data.	
:CALCulate2	Subsystem to control CALC 2:	4.13.2
:FORMat <name>	Select math format: MEAN, SDEViation, MAXimum, MINimum, PKPK, NONE.	
:FORMat?	Query math format.	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.	
:STATe?	Query state of math function.	
:IMMediate	Recalculate raw input data in buffer.	
:DATA?	Read math result of CALC 2.	
:CALCulate3	Subsystem to control CALC 3 (limit tests):	4.13.3
:LIMit[1]	Path to control LIMIT 1 test:	
:UPPer	Path to configure upper limit:	
[:DATA] <n>	Specify upper limit (-9.99e35 to +9.99e35).	
[:DATA]?	Query upper limit.	
:SOURce <NRf>	Specify digital output (0 to 15).	
:SOURce?	Query source.	
:LOWer	Path to configure lower limit:	
[:DATA] <n>	Specify lower limit (-9.99e35 to +9.99e35).	
[:DATA]?	Query lower limit.	
:SOURce <NRf>	Specify digital output (0 to 15).	
:SOURce?	Query source.	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.	
:STATe?	Query state of limit test.	
:FAIL?	Query test result (1=pass, 0=fail).	
:CLEAR	Path to clear failed test:	
[:IMMediate]	Clear failed test indication.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.	
:AUTO?	Query auto clear.	

Table 4-6 (cont.)
Calculate command summary

Command	Description	Reference
:CALCulate3		*4.13.3*
:LIMit2	Path to control LIMIT 2 test:	
:UPPer	Path to configure upper limit:	
[:DATA] <n>	Specify upper limit (-9.99e35 to +9.999999e35).	
[:DATA]?	Query upper limit.	
:SOURce <NRf>	Specify digital output (0 to 15).	
:SOURce?	Query source (digital output value).	
:LOWer	Path to configure lower limit:	
[:DATA] <n>	Specify lower limit (-9.99e35 to +9.999999e35).	
[:DATA]?	Query lower limit.	
:SOURce <NRf>	Specify digital output (0 to 15).	
:SOURce?	Query source (digital output value).	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.	
:STATe?	Query state of limit test.	
:FAIL?	Query test result (1=pass, 0=fail).	
:CLEAR	Path to clear failed test:	
[:IMMediate]	Clear failed test indication.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.	
:AUTO?	Query auto clear.	
:PASS	Path to define "pass" digital output pattern.	
:SOURce <NRf>	Specify digital output (0 to 15).	
:CLIMits	Command path for composite limits:	
:FAIL?	Query composite result of LIMIT 1 and LIMIT 2 tests (1=pass, 0=fail).	
:BSTRobe	Path to control limit binning strobe:	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) strobe.	
:STATe?	Query state of binning strobe.	
:IMMediate	Re-perform limit tests.	

Notes:
1. Brackets [ ] are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets [ ] in the program message.
2. Angle brackets < > are used to indicate parameter type. Do not use angle brackets < > in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.13.1 :CALCulate[1]

This subsystem is used to configure and control the mX+b and Percent math calculations.

:FORMat <name>

:CALCulate[1]:FORMat <name> Specify CALC 1 format

Parameters

<name>	= MXB	mX+b math calculation
	= PERCent	Percent math calculation
	= PDEViation	Percent deviation math calculation
	= NONE	No calculation

Format :calc:form mxb <name>

Defaults

Power-up	Saved power-on setup
*RST	PERCent
:SYSTem:PRESet	PERCent

Query

:FORMat?	Query programmed math format
Short-form format:	:calc:form?
Response message:	MXB, PERC, PDEV, or NONE

Description This command is used to specify the format for the CALC 1 math calculation. With NONE selected, no CALC 1 calculation will be performed. With one of the other formats selected and CALC 1 enabled (see :STATe), the result of the calculation will be displayed. The calculated reading will be refreshed every time the instrument takes a reading.

mX+b: This calculation multiplies a constant (m) times the input reading (X) and adds an offset (b). Note that if a reference (see Sense1 subsystem) is established, then X = input signal - reference.

Percent: This calculation is performed as follows:

$$\text{Percent} = \frac{X}{\text{Target Value}} \times 100$$

where; X = input signal - reference (reference is zero if :REFerence is disabled; see Sense1 subsystem).

Percent deviation: See paragraph 3.10.3.

Programming example

```
10  OUTPUT 716; ":calc:form  mxb; form?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects the mX+b math format, and the second queries the programmed format.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed math format for CALC 1 (MXB).

:KMATh commands

:MMFactor <NRf>

:CALCulate[1]:KMATh:MMFactor <NRf> Specify "m" factor

Parameter <NRf> = -9.999999e35 to +9.999999e20 Specify "m" factor for mX+b calculation.

Format :calc:kmat:mmf <NRf>

Defaults

Power-up	Saved power-on setup
*RST	"m" = 1
:SYSTem:PRESet	"m" = 1

Query

:MMFactor?	Query "m" factor for mX+b
Short-form format:	:calc:kmat:mmf?
Response message:	-9.999999e35 to +9.999999e20

Description This command is used to define the "m" factor for the CALC 1 mX+b calculation.

Programming example

```
10  OUTPUT 716; ":calc:kmat:mmf  2; mmf?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first sets the "m" factor to two, and the second queries the programmed "m" factor.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the "m" factor (2).

:MBFactor <NRf>

:CALCulate[1]:KMATh:MBFactor <NRf> Specify "b" factor

Parameter <NRf> = -9.999999e35 to +9.999999e30 Specify "b" factor for mX+b calculation.

Format :calc:kmat:mbf <NRf>

Defaults

Power-up	Saved power-on setup
*RST	"b" = 0
:SYSTem:PRESet	"b" = 0

Query

:MBFactor?	Query "b" factor for mX+b
Short-form format:	:calc:kmat:mbf?
Response message:	-9.999999e35 to +9.999999e30

Description This command is used to define the "b" factor for the CALC 1 mX+b calculation.

Programming example

```
10  OUTPUT 716; ":calc:kmat:mbf  2; mbf?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first sets the "b" factor to two, and the second queries the programmed "b" factor.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the "b" factor (2).

:PERCent <NRf>

:CALCulate[1]:KMATh:PERCent <NRf> Specify Percent target value

Parameter <NRf> = -9.999999e35 to +9.999999e35 Specify target value for Percent calculation.

Format :calc:kmat:perc <NRf>

Defaults

Power-up	Saved power-on setup
*RST	1
:SYSTem:PRESet	1

Query :PERCent?
Short-form format: :calc:kmat:perc?
Response message: -9.999999e35 to +9.999999e35

Description This command is used to specify the target value for the Percent calculation.

Programming example

```
10  OUTPUT 716; ":calc:kmat:perc  10; perc?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first sets the target value to 10, and the second queries the programmed target value.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the target value (10).

:STATe <b>

:CALCulate[1]:STATe <b> Control CALC 1

Parameters

<b>	= 0 or OFF	Disable CALC 1 calculation
	= 1 or ON	Enable CALC 1 calculation

Format :calc:stat <b>

Defaults

Power-up	Saved power-on setup
*RST	ON
:SYSTem:PRESet	OFF

Query :STATe? Query state (on or off) of CALC 1
Short-form format: :calc:stat?
Response message: 1 (on) or 0 (off)

Description This command is used to enable or disable the CALC 1 calculation. When enabled, each instrument reading will reflect the selected calculation (see :FORMat).

Programming example

```
10  OUTPUT 716; ":calc:stat  on; stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first enables the CALC 1 calculation and the second queries the programmed state.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of CALC 1 (1; on).

:DATA?

:CALCulate[1]:DATA? Read CALC 1 result

Format :calc:data?

Description This query command is used to read the result of the CALC 1 calculation. After sending this command and addressing the Model 2001 to talk, the CALC 1 reading will be sent to the computer. If CALC 1 is disabled or NONE is selected, the "raw" reading will instead be read.

Programming example

```
10 OUTPUT 716; ":calc:data?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Queries the CALC 1 reading.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the CALC 1 reading.

:IMMediate

:CALCulate[1]:IMMediate Recalculate CALC 1

Format :calc:imm

Query :IMMediate? Perform calculation and read result (equivalent to :CALCulate[1]:IMMediate; DATA?)
Short-form format: :calc:imm?
Response message: Result of calculation

Description When you change the math calculation, the next instrument reading will reflect the new calculation (assuming CALC 1 math is enabled). If the instrument is not in a continuous measurement mode (i.e. waiting for a manual trigger), the displayed reading will not update to the reflect the new calculation until the next reading conversion occurs.

This action command allows you to reprocess the current input data to reflect a new calculation. For example, assume the instrument is in a non-continuous measurement mode and requires a manual trigger to cause the next reading conversion. Changing the calculation will not affect the currently displayed reading. However, sending the :IMMediate command will reprocess that displayed reading to reflect the new calculation. Note that sending the :IMMediate command does not initiate a reading conversion.

An alternate way to perform the calculation and read the result is by using the query form of the command (:IMMediate?). When this command is sent, the calculation is performed and the result is queried. The result of the calculation will be sent to the computer when the Model 2001 is addressed to talk.

Programming example

```
OUTPUT 716; ":trig:sour  bus"
OUTPUT 716; ":calc:form  mxb; stat  on; kmat:mmf  1; mbf  50"
OUTPUT 716; "calc:imm"
```

First Program Message: Sets the measure control source for bus triggers. This places the instrument in a non-continuous measurement mode. The last reading will remain displayed.

Second Program Message: Four commands in this message; the first selects the mX+b calculation, the second enables the calculation, the third sets the "m" factor to one, and the last command sets the "b" factor to 50. Notice that after these commands are executed, the displayed reading will not change.

Third Program Message: Immediately updates the displayed reading to reflect the mX+b calculation. In this case, a value of 50 was added to the reading.

4.13.2 :CALCulate2

This Calculate subsystem is used to configure and control CALC 2 operations on readings stored in the buffer.

:FORMat <name>

:CALCulate2:FORMat <name> Specify CALC 2 format

Parameters

<name>	= MEAN	Mean value of readings in buffer
	= SDEV	Standard deviation of readings in buffer
	= MAX	Largest reading in buffer
	= MIN	Lowest reading in buffer
	= PKPK	Peak-to-peak value of readings in buffer
	= NONE	No calculation

Format

:calc2:form <name>

Defaults

Power-up	Saved power-on setup
*RST	NONE
:SYSTem:PRESet	NONE

Query

:FORMat?	Query programmed math format
Short-form format:	:calc2:form?
Response message:	MEAN, SDEV, MAX, MIN, PKPK or NONE

Description

This command is used to specify the format for the CALC 2 math calculation. The calculation operations for CALC 2 use data stored in the buffer.

With NONE selected, no CALC 2 calculation will be performed. With one of the other formats selected and CALC 2 enabled (see :STATe), the calculation will be performed every time the :IMMediate or :IMMediate? command is executed.

MEAN: This math format calculates the mean value for all the readings stored in the buffer. Mean (y) is calculated as follows:

$$y = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: X_i is a stored reading, and
n is the number of stored readings.

SDEV: This math format calculates the standard deviation for all the readings stored in the buffer. Standard deviation (y) is calculated as follows:

$$y = \sqrt{\frac{\sum_{i=1}^{n} X_i^2 - \left(\frac{1}{n}\left(\sum_{i=1}^{n} X_i\right)^2\right)}{n-1}}$$

where: X_i is a stored reading, and
n is the number of stored readings.

MAX: This math format is used to determine the largest reading that is stored in the buffer.

MIN: This math format is used to determine the lowest reading that is stored in the buffer.

PKPK: This math format is used to determine the peak to peak value for the readings stored in the buffer. The peak to peak value is calculated as follows:

PKPK = MAX - MIN

where; MAX is that largest reading in the buffer
MIN is the lowest reading in the buffer

Programming example

```
10  OUTPUT 716; ":calc2:form  max; form?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects the MAX math format, and the second queries the programmed format.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed math format for CALC 2 (MAX).

:STATe <b>

:CALCulate2:STATe <b> Control CALC 2

Parameters

<b>	= 0 or OFF	Disable CALC 2 calculation
	= 1 or ON	Enable CALC 2 calculation

Format :calc2:stat <b>

Defaults

Power-up	Saved power-on setup
*RST	ON
:SYSTem:PRESet	OFF

Query

:STATe?	Query state (on or off) of CALC 2
Short-form format:	:calc2:stat?
Response message:	1 (on) or 0 (off)

Description This command is used to enable or disable the CALC 2 calculation. When enabled, the selected CALC 2 format will be calculated when the :IMMediate or :IMMediate? command is executed.

Programming example

```
10  OUTPUT 716; ":calc2:stat  on; stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first enables the CALC 2 calculation and the second queries the programmed state.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of CALC 2 (1; on).

:IMMediate

:CALCulate2:IMMediate Perform CALC 2

Format :calc2:imm

Query

:IMMediate?	Perform calculation and read result (equivalent to :CALCulate2:IMMediate; DATA?)
Short-form format:	:calc2:imm?
Response message:	Result of calculation

Description The :IMMediate command is used to perform the selected CALC 2 operation on the readings in the buffer (assuming CALC 2 is enabled; see :STATe). After performing the calculation, the result can be read by using the :CALCulate2:DATA? query command.

An alternate way to perform the calculation and read the result is by using the query form of the command (:IMMediate?). When this command is sent, the calculation is performed and the result is queried. The result of the calculation will be sent to the computer when the Model 2001 is addressed to talk.

Programming example This example assumes that there are readings stored in the buffer and CALC 2 is enabled:

```
10  OUTPUT 716; ":calc2:form  max"
20  OUTPUT 716; ":calc2:imm?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Selects the MAX math format.

Line 20 Performs the math operation and queries the result.
Line 30 Addresses Model 2001 to talk.
Line 40 Displays the largest (MAX) reading in the buffer.

:DATA?

:CALCulate2:DATA? Read CALC 2 result

Format :calc2:data?

Description This query command is used to read the result of the CALC 2 operation. After sending this command and addressing the Model 2001 to talk, the CALC 2 reading will be sent to the computer. If CALC 2 is disabled or NONE is selected, the "raw" reading will instead be read.

Note that this command does not initiate a calculation. This command is used to simply read the result of the last calculation.

Programming example

```
10 OUTPUT 716; ":calc2:data?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Queries the CALC 2 reading.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the CALC 2 reading.

4.13.3 :CALCulate3

This Calculate subsystem is used to configure and control the limit tests (LIMIT 1 test and LIMIT 2 test). Limits are tested in the following sequence:

1. Low Limit 1
2. High Limit 1
3. Low Limit 2
4. High Limit 2

The first failure in the test sequence determines the digital pattern that is applied to the output port. For example, if the upper limit for LIMIT 1 (High Limit 1) fails, the programmed digital pattern for that limit is applied to the output port. A failure in the rest of the test sequence will not change the digital pattern to the output port.

If all limits in the test sequence pass, then the programmed "pass" digital pattern is instead applied to the output port.

Note that if a limit test is disabled, then those limits are simply not tested.

[:DATA] <n>

:CALCulate3:LIMit[1]:UPPer[:DATA] <n>	Specify upper LIMIT 1
:CALCulate3:LIMit[1]:LOWer[:DATA] <n>	Specify lower LIMIT 1
:CALCulate3:LIMit2:UPPer[:DATA] <n>	Specify upper LIMIT 2
:CALCulate3:LIMit2:LOWer[:DATA] <n>	Specify lower LIMIT 2

Parameters

<n>	= -9.999999e35 to +9.999999e35	Specify limit value
	= DEFault	Set specified upper limit to 1
		Set specified lower limit to -1
	= MINimum	Set specified limit to -9.999999e35
	= MAXimum	Set specified limit to +9.999999e35

Formats

:calc3:lim:upp <n>	:calc3:lim:low <n>
:calc3:lim2:upp <n>	:calc3:lim2:low <n>

Defaults

Power-up	Saved power-on setup
*RST	Upper limits = 1
	Lower limits = -1
:STATus:PRESet	Upper limits = 1
	Lower limits = -1

Query

:UPPer?	Query specified upper limit
:UPPer? DEFault	Query *RST default upper limit
:UPPer? MINimum	Query lowest allowable upper limit
:UPPer? MAXimum	Query largest allowable upper limit
:LOWer?	Query specified lower limit
:LOWer? DEFault	Query *RST default lower limit
:LOWer? MINimum	Query lowest allowable lower limit
:LOWer? MAXimum	Query largest allowable lower limit

Short-form formats:

:calc3:lim:upp?	:calc3:lim:low?
:calc3:lim:upp? xxx	:calc3:lim:low? xxx
:calc3:lim2:upp?	:calc3:lim2:low?
:calc3:lim2:upp? xxx	:calc3:lim2:low? xxx

where; xxx = def, min or max

Response message: -9.999999e35 to +9.999999e35

Description

These commands are used to set the upper and lower limits for LIMIT 1 and LIMIT 2. The actual limit depends on which measurement function is currently selected. For example, a limit value of 1 is 1V for the volts functions (DCV or ACV), 1A for the current functions (DCI or ACI), 1Ω on the ohms functions (Ω2 or Ω4), and 1° (C, F or K) for the temperature function (TEMP). The upper limit value is not range sensitive. An upper limit of 2 for DCV is 2V on all measurement ranges. Note that limit tests cannot be performed on frequency (FREQ) measurements.

Programming example

```
10  OUTPUT 716; ":calc3:lim:upp  10; upp?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the upper limit of LIMIT 1 to 10, and then queries the programmed limit.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the upper limit of LIMIT 1 (10).

:SOURce <NRf>

:CALCulate3:LIMit[1]:UPPer:SOURce <NRf>	Specify pattern; upper LIMIT 1 failure
:CALCulate3:LIMit[1]:LOWer:SOURce <NRf>	Specify pattern; lower LIMIT 1 failure
:CALCulate3:LIMit2:UPPer:SOURce <NRf>	Specify pattern; upper LIMIT 2 failure
:CALCulate3:LIMit2:LOWer:SOURce <NRf>	Specify pattern; lower LIMIT 2 failure

Parameter <NRf> = 0 to 15 Specify digital pattern for output port

Formats
:calc3:lim:upp:sour <NRf>
:calc3:lim:low:sour <NRf>
:calc3:lim2:upp:sour <NRf>
:calc3:lim2:low:sour <NRf>

Defaults

Power-up	Saved power-on setup
*RST	0
:SYSTem:PRESet	0

Query

:SOURce?	Query source value for specified limit
Short-form formats:	:calc3:lim:upp:sour?
	:calc3:lim:low:sour?
	:calc3:lim2:upp:sour?
	:calc3:lim2:low:sour?
Response message:	0 to 15

Description These commands are used to specify which line(s) of the Digital Output Port will go true when a limit test failure occurs. The first failure in the test sequence determines the digital output pattern. Subsequent failures in the test sequence will not change the digital output pattern on the output port.

Each output line is assigned a decimal weight as follows:

Digital Output	Decimal Weight
Line #1	1
Line #2	2
Line #3	4
Line #4	8

The parameter value for the digital pattern is determined by adding the decimal weights of the desired output lines. For example, if you want output lines #2 and #3 to go true when the upper limit of LIMIT 1 is the first failure in the test sequence, use a parameter value of 6 (2+4) as follows:

:calc3:lim:upp:sour 6

The actual true state (high or low) of each Digital Output line depends on its programmed polarity. If programmed for active-high polarity, the output line will go high (true) when the upper

limit of LIMIT 1 is the first failure. If programmed for active-low polarity, the output line will go low (true) when the upper limit of LIMIT 1 is the first failure. Polarity is programmed from the Output subsystem (see paragraph 4.17).

Note that when the binning strobe is enabled (see :BSTRobe command path), output line #4 is not considered to be part of the digital output pattern. The binning strobe uses line #4. With the binning strobe enabled, parameters 8 through 15 are treated the same as parameters 0 through 7.

Programming example

```
10  OUTPUT 716; ":calc3:lim:upp:sour  4; sour?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Specifies output line #3 to go true if the upper limit of LIMIT 1 is exceeded, and then queries the source value.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the source value (4).

:STATe <b>

:CALCulate3:LIMit[1]:STATe <b> Control LIMIT 1 test
:CALCulate3:LIMit2:STATe <b> Control LIMIT 2 test

Parameters

<b>	= 1 or ON	Enable specified limit test
	= 0 or OFF	Disable specified limit test

Formats

:calc3:lim:stat <b>
:calc3:lim2:stat <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF (both limit tests)
:SYSTem:PRESet	OFF (both limit tests)

Query

:STATe?	Query state of specified limit test
Short-form formats:	:calc3:lim:stat?
	:calc3:lim2:stat?
Response message:	0 (off) or 1 (on)

Description

These commands are used to enable or disable LIMIT 1 and LIMIT 2 tests. When enabled, the test sequence for limits will be performed every time the instrument performs a measurement. Testing is performed in the following sequence: Low Limit 1, High Limit 1, Low Limit 2 and High Limit 2. Any limit test (LIMIT 1 or LIMIT 2) not enabled is simply not performed.

The first failure in the test sequence will determine which digital pattern will be applied to the output port. For example, if the lower limit of LIMIT 1 fails, the digital pattern defined for LIMIT 1 lower limit failures will be applied to the output port. The other tests will still be performed, but a failure will not change the digital pattern on the output port.

If both the lower and upper limits of LIMIT 1 pass, the test sequence will proceed on to test the limits of LIMIT 2 (if enabled). If all the enabled test limits pass, then the programmed "pass" digital pattern (see :PASS:SOURce) will be applied to the output port.

Note that when a limit test (LIMIT 1 or LIMIT 2) is enabled, the digital output port cannot be controlled from the Source subsystem.

When LIMIT 1 or LIMIT 2 is disabled, the respective limit tests will, of course, not be included in the test sequence. Also, a fail indication (see :FAIL?) for LIMIT 1 or LIMIT 2 will be cleared when the respective limit test is disabled.

Programming example

```
10  OUTPUT 716; ":calc3:lim:stat  on; stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables LIMIT 1 test, and then queries the state of LIMIT 1.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of LIMIT 1 (1; on).

:FAIL?

:CALCulate3:LIMit[1]:FAIL?	Read LIMIT 1 test results
:CALCulate3:LIMit2:FAIL?	Read LIMIT 2 test results

Formats

:calc3:lim:fail?
:calc3:lim2:fail?

Description

These commands are used to read the results of LIMIT 1 and LIMIT 2 tests. After sending one of these commands and addressing the Model 2001 to talk, a value (0 or 1) will be sent to the computer:

0 = Limit test passed
1 = Limit test failed

The response message (0 or 1) only tells you if a limit test has passed or failed. It does not tell you which limit (upper or lower) has failed. To determine which limit has failed, you will have to read the Measurement Event Register (see paragraph 4.6.6).

Reading the results of a limit test does not clear the fail indication of the test. A failure can be cleared by using a :CLEar command, or by disabling the test (:STATe OFF).

Programming example

This example assumes that LIMIT 1 test has been performed.

```
10  OUTPUT 716; ":calc3:lim:fail?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Queries the result of LIMIT 1 test.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the result of LIMIT 1 test.

:CLEar commands

[:IMMediate]

:CALCulate3:LIMit[1]:CLEar[:IMMediate] Clear LIMIT 1 test failure
:CALCulate3:LIMit2:CLEar[:IMMediate] Clear LIMIT 2 test failure

Formats

:calc3:lim:cle
:calc3:lim2:cle

Description

These action commands are used to clear the fail indication of LIMIT 1 and LIMIT 2 tests. Note that a failure is also cleared when the limit test is disabled (:STATe OFF).

Programming example

```
OUTPUT 716; ":calc3:lim:cle"      ! Clear fail condition of LIMIT 1 test.
```

:AUTO <b>

:CALCulate3:LIMit[1]:CLEar:AUTO <b> Control auto-clear; LIMIT 1
:CALCulate3:LIMit2:CLEar:AUTO <b> Control auto-clear; LIMIT 2

Parameters

<b>	= 1 or ON	Enable auto-clear for limit failure
	= 0 or OFF	Disable auto-clear for limit failure

Formats

:calc3:lim:cle:auto <b>
:calc3:lim2:cle:auto <b>

Defaults

Power-up	Saved power-on setup
*RST	ON
:SYSTem:PRESet	ON

Query

:AUTO?	Query state of auto clear
Short-form formats:	:calc3:lim:cle:auto?
	:calc3:lim2:cle:auto?
Response message:	1 (on) or 0 (off)

Description

With auto-clear enabled, the fail indication of a limit test will clear when instrument operation enters the idle state of the Trigger Model. With auto-clear disabled, the fail indication will remain until it is cleared by the :CLEar[:IMMediate] command.

Programming example

```
10  OUTPUT 716; ":calc3:lim:cle:auto  on; auto?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables auto-clear, and then queries the state of auto-clear.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of auto-clear (1; on).

:PASS:SOURce <NRf>

:CALCulate3:PASS:SOURce <NRf> Specify "pass" pattern

Parameter <NRf> = 0 to 15 Specify digital pattern for output port

Format :calc3:pass:sour <NRf>

Defaults

Power-up	Saved power-on setup
*RST	0
:SYSTem:PRESet	0

Query

:SOURce?	Query programmed source value
Short-form format:	:calc3:pass:sour?
Response message:	0 to 15

Description This command is used to specify which line(s) of the Digital Output Port will go true when there are no failures in the limit tests.

Each output line is assigned a decimal weight as follows:

Digital Output	Decimal Weight
Line #1	1
Line #2	2
Line #3	4
Line #4	8

The parameter value for the digital pattern is determined by adding the decimal weights of the desired output lines. For example, if you want output lines #2 and #3 to go true when all enabled limit tests pass, use a parameter value of 6 (2+4).

The actual true state (high or low) of each Digital Output line depends on its programmed polarity. If programmed for active-high polarity, the output line will go high (true) when all enabled limit tests pass. If programmed for active-low polarity, the output line will go low (true) when all enabled limit tests pass. Polarity is programmed from the Output subsystem (see paragraph 4.17).

Note that when the binning strobe is enabled (see :BSTRobe command path), output line #4 is not considered to be part of the digital output pattern. The binning strobe uses line #4. With the strobe enabled, parameter values 8 through 15 are treated the same as parameters 0 through 7.

Programming example

```
10  OUTPUT 716; ":calc3:pass:sour  3; sour?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first specifies output line #3 to go true if all enabled limits pass, and the second queries the source value.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the source value (4).

:CLIMits:FAIL?

:CALCulate3:CLIMits:FAIL? Read composite result of limit tests

Format :calc3:clim:fail?

Description This query command is used to obtain the composite result of the LIMIT 1 and LIMIT 2 tests. The composite result is the logical OR'ed summary of LIMIT 1 and LIMIT 2.

After sending this command and addressing the Model 2001 to talk, a value (1 or 0) will be sent to the computer:

1 = One or both tests have failed.
0 = Both tests have passed.

In the event of a failure (1), you can determine which test(s) has failed by using the fail command of each limit (:LIMit1:FAIL? and :LIMit2:FAIL?).

This command (like the other fail commands) does not clear the fail indication for LIMIT 1 or LIMIT 2.

Programming example This example assumes that LIMIT 1 and LIMIT 2 tests have been performed.

```
10  OUTPUT 716; ":calc3:clim:fail?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Queries the composite result of the limit tests.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the composite result of the limit tests.

:BSTRobe:STATe <b>

:CALCulate3:BSTRobe:STATe <b> Control binning strobe

Parameters

<b>	= 1 or ON	Enable binning strobe
	= 0 or OFF	Disable binning strobe

Format :calc3:bstr <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:STATe?	Query state of binning strobe
Short-form format:	:calc3:bstr:stat?
Response message:	1 (on) or 0 (off)

Description This command is used to enable or disable the strobe for the binning operation. When enabled, digital output line #4 will be used for the binning strobe pulse. After the appropriate digital pattern is placed on the other three lines of the output port, the >10μsec strobe pulse will be asserted

on line #4. The strobe is used to "inform" your external binning circuit that the output port (lines 1, 2 and 3) is ready to be read.

The polarity of the strobe pulse is determined by the programmed polarity of output line #4 (see Output subsystem). If line #4 is programmed for active-high polarity, the binning strobe will be a positive-going pulse. Conversely, if programmed for active-low polarity, the strobe will be a negative-going pulse.

Programming example

```
10  OUTPUT 716; ":calc3:bstr   on; bstr?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first enables the binner strobe, and the second queries the state of the strobe.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the state of the binner strobe (1; on).

:IMMediate

:CALCulate3:IMMediate Perform CALC 3

Format

```
:calc3:imm
```

Description

When you change the configuration of the limit test, the next reading will be evaluated according to that new test configuration. If the instrument is not in a continuous measurement mode (e.g., waiting for a manual trigger), the test will not be performed until the next reading conversion occurs.

This action command allows you to re-process the current input data to test new limits. For example, assume the instrument is in a non-continuous measurement mode and requires a manual trigger to cause the next reading conversion. Changing the test limits will not affect the last test result. However, sending the :IMMediate command will re-process the data and evaluate the reading according to the new test limits. Note that sending the :IMMediate command does not initiate a reading conversion.

Programming example

This example assumes that the instrument is configured to perform a limit test.

```
OUTPUT 716 ":trig:sour   bus"
OUTPUT 716 ":calc3:imm"
```

The first message places the instrument in a "one-shot" measurement mode. While waiting for a bus trigger, the test limit configuration can be changed. The second message re-performs the limit test on the same reading.

4.14 :CALibration subsystem

The commands in this subsystem are summarized in Table 4-7. Details on using these commands to calibrate the Model 2001 are contained in the Model 2001 Calibration Manual.

Table 4-7
CALibrate command summary

Command	Description
:CALibration	Calibration root command.
:PROTected	All commands in this subsystem are protected by the CAL switch.
:LOCK	Lock out calibration (opposite of enabling cal with CAL switch).
:SWITch?	Request comprehensive CAL switch state. (0 = locked; 1 = unlocked)
:SAVE	Save cal constants to EEPROM.
:DATA?	Download cal constants from 2001.
:DATE "<string>"	Send cal date to 2001.
:DATE?	Request cal date from 2001.
:NDUE "<string>"	Send next due cal date to 2001.
:NDUE?	Request next due cal date from 2001.
:LLEVel	Low-level calibration subsystem.
:SWITch?	Request low-level CAL switch state. (0 = locked; 1 = unlocked)
:STEP <Step #>	
1	20V AC at 1kHz step.
2	20V AC at 30kHz step.
3	200V AC at 1kHz step.
4	200V AC at 30kHz step.
5	1.5V AC at 1kHz step.
6	0.2V AC at 1kHz step.
7	5mV AC at 100kHz step.
8	0.5mV AC at 1kHz step.
9	+2V DC step.
10	-2V DC step.
11	0V DC step.
12	20mA AC at 1kHz step.
13	+0.2A DC step.
14	+2A DC step.
15	2V AC at 1Hz step.
:STEP?	Request the current calibration step.
:CALCulate	Calculate low-level cal constants.
:DC	User calibration subsystem.
:ZERO	Low-thermal short calibration step.
:LOW <NRf>	+2V DC calibration step.
:HIGH <NRf>	+20V DC calibration step.
:LOHM <NRf>	20kΩ calibration step.
:HOHM <NRf>	1MΩ calibration step.
:OPEN	Open circuit calibration step.
:CALCulate	Calculate DC cal constants.
:UNPRotected	All commands in this subsystem are not protected by CAL switch.
:ACCompensation	Perform user AC calibration (disconnect all cables).

Notes:
1. Brackets [ ] are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets [ ] in the program message.
2. Angle brackets < > are used to indicate parameter type. Do not use angle brackets < > in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.15 :DISPlay subsystem

The display subsystem controls the display of the Model 2001 and is summarized in Table 4-8.

Table 4-8
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:DATA?	Query data on top portion of display.
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:DATA?	Query data on bottom portion of display.
:CNDisplay	Clear NEXT (or PREV) display messages and cancels associated operations.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display.
:ENABle?	Query state of the display (0 or 1).

Notes:
1. Brackets [ ] are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets [ ] in the program message.
2. Angle brackets < > are used to indicate parameter type. Do not use angle brackets < > in the program message.
3. Upper case characters indicate the short-form version for each command word.

:TEXT commands

:DATA <a>

:DISPlay[:WINDow[1]]:TEXT:DATA <a> Define message for top display
:DISPlay:WINDow2:TEXT:DATA <a> Define message for bottom display

Parameter <a> = ASCII characters for message

Formats

String	:disp:text:data 'aa...a'
	:disp:wind2:data 'aa...a'
Indefinite block	:disp:text:data #0aa...a
	:disp:wind2:text:data #0aa...a
Definite block	:disp:text:data #XYaa...a
	:disp:wind2:text:data #XYaa...a

where; Y = number of characters in message:
Up to 20 for top display.
Up to 32 for bottom display.
X = number of digits that make up Y (1 or 2).

Defaults

Power-up	Null string
*RST	No effect
:SYSTem:PRESet	No effect

Query

:DATA?	Query the defined text message
Short-form formats:	:disp:text:data?
	:disp:wind2:text:data?
Response message:	User defined text message

Description

These commands define the text messages that you wish to display. The message can be as long as 20 characters for the top display, and up to 32 characters for the bottom display. A space is counted as a character. Excess message characters (over 20 and 32 respectively) will cause error.

A string message must be enclosed in single quotes or double quotes. Both of the following string messages are valid:

'My dog has fleas' or "My dog has fleas"

An indefinite block message must be the only command in the program message or the last command in the program message. If you include a command after an indefinite block message (on the same line), it will be treated as part of the message and will be displayed instead of executed.

Programming example

```
10  OUTPUT 716; ":disp:text:data  'Keithley Model 2001'; data?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Defines the user defined message for the top display, and then queries the defined message.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays (on the CRT) the user defined message.

:STATe <b>

:DISPlay[:WINDow[1]]:TEXT:STATe <b> Control (on/off) message; top display
:DISPlay:WINDow2:TEXT:STATe <b> Control (on/off) message; bottom display

Parameters

<b>	= 0 or OFF	Disable text message for specified display
	= 1 or ON	Enable text message for specified display

Formats

:disp:text:stat <b>
:disp:wind2:text:stat <b>

Defaults

Power-up	OFF
*RST	No effect
:SYSTem:PRESet	No effect

Query

:STATe?	Query state of message mode for specified display
Short-form formats:	:disp:text:stat?
	:disp:wind2:text:stat?
Response message:	1 (on) or 0 (off)

Description

These commands enable and disable the text message modes. When enabled, a defined message (see previous command) will be shown on the top or bottom portion of the display. When disabled, the message will be removed from the display, and the Model 2001 will resume normal operation.

A user defined text message remains displayed only as long as the instrument is in remote. Taking the instrument out of remote (by pressing the LOCAL key or sending LOCAL 716), cancels the message and disables the text message mode.

Programming example

```
10  OUTPUT 716; ":disp:text:stat  on; stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Displays a defined user message (see previous command) on the top display, and then queries the state (on or off) of the display.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays (on the CRT) the state of the message mode (1; on).

:DATA?

:DISPlay[:WINDow[1]]:DATA?	Read top display
:DISPlay:WINDow2:DATA?	Read bottom display

Format

:disp:data?

Description

These query commands are used to read what is currently being displayed on the top and bottom displays. After sending one of these commands and addressing the Model 2001 to talk, the displayed data (message or reading) will be sent to the computer.

Programming example

```
10  OUTPUT 716; ":disp:data?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Query the message or reading currently being displayed on the top portion of the display.

Line 20 Addresses the Model 2001 to talk.

Line 30 Display on the CRT the Model 2001 message or reading.

:CNDisplay

:DISPlay:CNDisplay	Clear (cancel) NEXT display

Format

:disp:cnd

Description This action command is used to clear the bottom display of NEXT (or PREV) messages and cancel the operations associated with them. This command has no effect on any other message types.

Programming example This programming example assumes that a NEXT operation is currently being displayed.

```
OUTPUT 716; ":cnd"          ! Clears NEXT display.
```

:SMESsage <b>

:DISPlay:SMESsage <b> — Control status message

Parameters

<b>	= 0 or OFF	Disable status messages
	= 1 or ON	Enable status messages

Format :disp:smes <b>

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:SMESsage?	Query state of status message mode
Short-form format:	:disp:smes?
Response message:	1 (on) or 0 (off)

Description This command is used to enable/disable the status message mode for the Model 2001. The status message mode is a diagnostic tool that provides real-time messages that relate to the current operating state of the instrument. See Table 3-4 for a list of status messages.

Programming example

```
10  OUTPUT 716; ":disp:smes  on; smes?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables the status message mode, and then queries the state of the message mode.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of the status message mode (1; on).

:ENABle <b>

:DISPlay:ENABle <b> — Control display circuitry

Parameters

<b>	= 0 or OFF	Disable display circuitry
	= 1 or ON	Enable display circuitry

Format :disp:enab <b>

Defaults

Power-up	ON
*RST	No effect
:SYSTem:PRESet	No effect

Query

:ENABle? Query state of display
Short-form format: :disp:enab?
Response message: 1 (on) or 0 (off)

Description

This command is used to enable and disable the front panel display circuitry. Disabling the display circuitry allows the instrument to operate at a higher speed. While disabled, the display will be frozen with the following message:

FRONT PANEL DISABLED
Press LOCAL to resume.

As reported by the message, all front panel controls (except LOCAL) will be disabled. Normal display operation can be resumed by using the :ENABle command to enable the display or by pressing the LOCAL key.

Programming example

```
10 OUTPUT 716; ":disp:enab off; enab?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Disables the display, and then queries the state of the display.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays (on the CRT) the programmed state of the display (0; off).

4.16 :FORMat subsystem

The commands for this subsystem are used to select the data format for transferring instrument readings over the bus. The BORDer command and DATA command affect readings transferred from the buffer ONLY. (i.e. SENSE:DATA? or CALC:DATA? will always be sent in ASCII.) These commands are summarized in Table 4-9.

Table 4-9
FORMat command summary

Command	Description
:FORMat	
[:DATA] <type>[,<length>]	Select data format: ASCii, REAL,32, REAL,64, SREal or DREal.
[:DATA]?	Query data format.
:ELEMents <item list>	Specify data elements: READing, CHANnel, RNUMber, UNITs, TIMEstamp and STATus.
:ELEMents?	Query data elements.
:BORDer <name>	Select binary byte order: NORMal, SWAPped.
:BORDer?	Query byte order.
:EXPonent <name>	Set exponent format: NORMal, HPRecision.
:EXPonent?	Query exponent format.

Notes:
1. Brackets [ ] are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets [ ] in the program message.
2. Angle brackets < > are used to indicate parameter type. Do not use angle brackets < > in the program message.
3. Upper case characters indicate the short-form version for each command word.

[:DATA] <type>[,length]

:FORMat[:DATA] <type>[,<length>] Specify data format

Parameters

<type>[,<length>]	= ASCii	ASCII format
	= REAL,32	IEEE754 single precision format
	= REAL,64	IEEE754 double precision format
	= SREal	IEEE754 single precision format
	= DREal	IEEE754 double precision format

NOTES:

1. When using the ASCii, SREal or DREal parameter, a <length> parameter is not required.
2. If you do not use a <length> parameter with the REAL parameter, the <length> will default to 32 (single precision format).

Formats

```
:form asc
:form real
:form real, 64
:form sre
:form dre
```

Defaults

Power-up	Saved power-on setup
*RST	ASCII
:SYSTem:PRESet	ASCII

Query

:DATA]?	Query data format
Short-form format:	:form?
Response message:	ASC, REAL,32, REAL,64, SRE or DRE

Description

This command is used to select the data format for transferring readings over the bus. For every reading conversion, the data string sent over the bus will contain the elements specified by the :ELEMents command. The specified elements are sent in a particular order.

The ASCII data format is in a direct readable form for the operator. Most basic languages will easily convert ASCII mantissa and exponent to other formats. However, some speed is compromised to accommodate the conversion. Figure 4-19 shows the ASCII format that includes all the data elements. Remember that only the specified elements will be included in each data string.

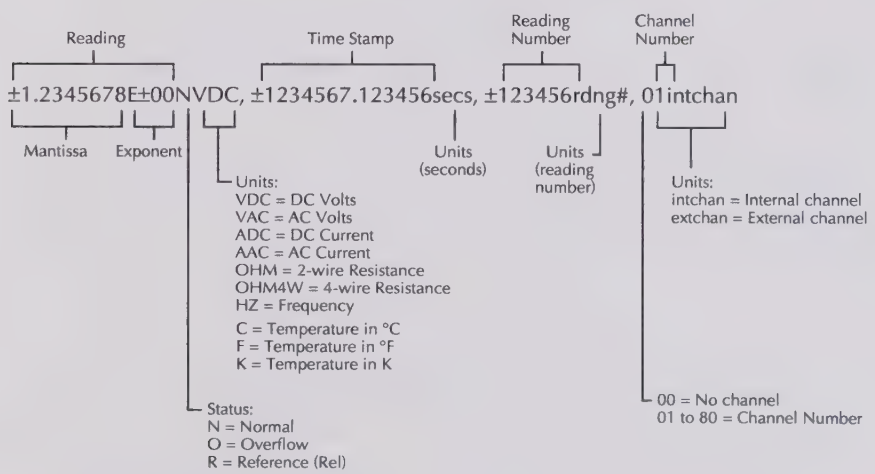
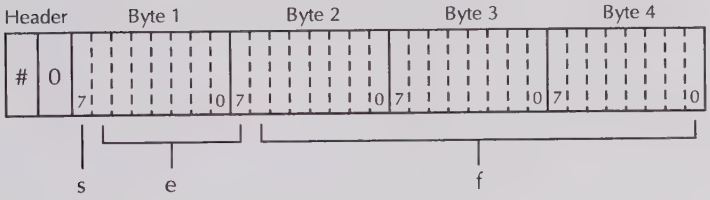


Figure 4-19
ASCII data format

REAL,32 or SREal will select the binary IEEE754 single precision data format. Figure 4-20 shows the normal byte order format for each data element. For example, if three valid elements are specified, the data string for each reading conversion will be made up of three 32-bit data blocks. Note that the data string for each reading conversion is preceded by a 2-byte header that is the binary equivalent of an ASCII # sign and 0.



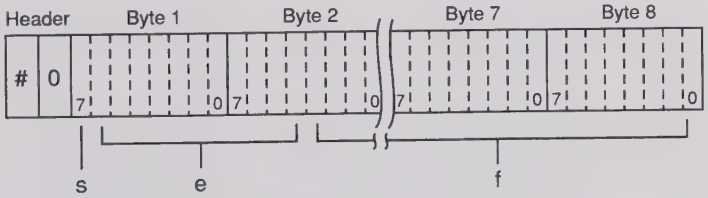
s = sign bit (0 = positive, 1 = negative)
e = exponent bits (8)
f = fraction bits (23)

Normal byte order shown. For swapped byte order, bytes sent in reverse order: Header, Byte 4, Byte 3, Byte 2, Byte 1.

The Header is only sent once for each measurement conversion.

Figure 4-20
IEEE754 single precision data format (32 data bits)

REAL,64 or DREal will select the binary IEEE754 double precision data format and is shown in Figure 4-21 (normal byte order shown). This format is similar to the single precision format except that it is 64 bits long.



Bytes 3, 4, 5, and 6 not shown.

s = sign bit (0 = positive, 1 = negative)
e = exponent bits (11)
f = fraction bits (52)

Normal byte order shown. For swapped byte order, bytes sent in reverse order: Header, Byte 8, Byte 7 .... Byte 1.

The Header is only sent once for each measurement conversion.

Figure 4-21
IEEE754 double precision data format (64 data bits)

Programming example

```
10  OUTPUT 716; ":form  SRE; form?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects the single precision binary data format, and the second queries the data format.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays SRE indicating IEEE754 single precision format is selected.

:ELEMents <item list>

:FORMat:ELEMents <item list> Specify data elements for data string

Parameters

<item list>:		
	READing	Includes reading in data string
	CHANnel	Includes channel number
	RNUMber	Includes reading number
	UNITs	Includes units
	TIMEstamp	Includes time stamp
	STATus	Includes status of reading

NOTE: Each item in the list must be separated by a comma (,).

Format :form:elem <item list>

Defaults

Power-up	Saved power-on setup
*RST	READing
:SYSTem:PRESet	All elements

Query

:ELEMents?	Query elements in data string
Short-form format:	:form:elem?
Response message:	READ, CHAN, RNUM, UNIT, TIME, STAT

NOTE: Only the programmed elements are included in the response message.

Description This command is used to specify the elements to be included in the data string for each measurement conversion. You can specify from one to all six elements. Each element in the list must be separated by a comma (,). These elements, shown in Figure 4-19, are explained as follows:

READing: Instrument reading. The resolution of this reading tracks the display resolution of the instrument. An overflow reading will read as +9.9E37.

CHANnel: Corresponds the instrument reading to the channel number of a switching card. If not scanning, the channel number will be 00.

RNUMber: The instrument keeps track of the number of readings it has performed. This reading counter starts at zero when the instrument is turned on. When a reading is sent over the bus (i.e. :FETCh?), the RNUMber element will indicate the reading number. The instrument also keeps track of the number of readings it has stored in the buffer. When buffer readings are sent over the bus (:TRACe:DATA?), each reading number will be referenced to the first reading, which is

#0, stored in the buffer. If using Pre-trigger to store readings, the pre-trigger readings will be assigned negative numbers.

UNITs: This element attaches the function unit to the reading, the time unit (sec) to the timestamp, and the channel unit (internal or external) to the channel number. An internal channel refers to an internally installed switching card (such as the Model 2001 SCAN) channel, while an external channel refers to the channel from an external switch system. This element is not available for the binary formats.

TIMEstamp: This is simply a timer that is used to reference each reading to a point in time. The timer starts at zero seconds when the instrument is turned on. After 99,999.999999 seconds, the timer will reset to zero seconds and start over. When a reading is sent over the bus (i.e. FETCh?), the TIMEstamp element will indicate the time that the reading was taken. The instrument also provides a time-stamp for readings stored in the buffer. When buffer readings are sent over the bus (:TRACe:DATA?), the time-stamp for each reading will be referenced to the first reading, which is time-stamped at 0 seconds, stored in the buffer. If using Pre-trigger to store readings, each pre-trigger reading will have a negative time-stamp.

STATus: This element indicates if the reading is normal (N), overflowed (O) or referenced (R) to another value. This element is not available for the binary formats.

The ASCII format shown in Figure 4-19 shows the byte order of the data string. Keep in mind that the byte order can only be reversed for the binary formats.

When using this command to add an element, you must include all elements that you want in the format. For example, if the reading is already specified and you want to add the time-stamp, you must include the READing parameter.

:form:elem time, read

Data elements for the item list can be listed in any order, but are always sent in the order shown in Figure 4-19.

NOTE

At power-on, all data elements will be selected. If the SCPI fetch format is selected (see :SYSTem:FORMat:ELEMents command), sending *RST will select the READing element only.

Programming example

```
10  OUTPUT 716; ":form:elem  read, stat, unit, time; elem?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects four data elements, and the second queries the elements.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the elements (READ, UNIT, TIME, STAT).

:BORDer <name>

:FORMat:BORDer <name> Specify binary byte order

Parameters

<name>	= NORMal	Normal byte order for binary formats
	= SWAPped	Reverse byte order for binary formats

Format

:form:bord <name>

Defaults

Power-up	Saved power-on setup
*RST	SWAPped
:SYSTem:PRESet	SWAPped

Query

:BORDer?	Query byte order
Short-form format:	:form:bord?
Response message:	NORM or SWAP

This command is used to control the byte order for the IEEE754 binary formats. For normal byte order, the data format for each element is sent as follows:

Byte 1	Byte 2	Byte 3	Byte 4	(Single precision)
Byte 1	Byte 2	•••	Byte 8	(Double precision)

For reverse byte order, the data format for each element is sent as follows:

Byte 4	Byte 3	Byte 2	Byte 1	(Single precision)
Byte 8	Byte 7	•••	Byte 1	(Double precision)

The "#,0" Header is not affected by this command. The Header is always sent at the beginning of the data string for each measurement conversion.

The ASCII data format can only be sent in the normal byte order. The SWAPped selection is simply ignored when the ASCII format is selected.

Programming example

```
10  OUTPUT 716; ":form:bord  swap; bord?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first reverses the binary byte order, and the second queries the byte order.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the byte order (SWAP).

:EXPonent <name>

:FORMat:EXPonent <name> Set exponent format.

Parameters

<name> = NORMal Normal format
= HPRecision High-precision format

Query

:EXPonent? Query exponent format

Description

This command defines the exponent format. The default setting is NORMal, in which case the returned value is formatted according to the engineering units of the present range (for example, 0.0012341E+03 on the 2k, 20k, or 200k range). Choosing HPRecision selects the highest precision possible, so the above example would be returned as 1.2341234E+00 with three extra digits of precision.

Programming example

```
OUTPUT 716; ":form:exp hpr"
```

4.17 :OUTPut subsystem

The OUTPut subsystem is used to set polarities for the digital output port. Commands in this subsystem are summarized in Table 4-10.

Table 4-10
OUTPut command summary

Command	Description
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active high (AHIGH) or active low (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active high (AHIGH) or active low (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active high (AHIGH) or active low (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active high (AHIGH) or active low (ALOW).
:LSENse?	Query polarity of line 4.

Notes:
1. Brackets [ ] are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets [ ] in the program message.
2. Angle brackets < > are used to indicate parameter type. Do not use angle brackets < > in the program message.
3. Upper case characters indicate the short-form version for each command word.

:LSENse <name>

:OUTPut:TTL[1]:LSENse <name>	Set polarity of line #1
:OUTPut:TTL2:LSENse <name>	Set polarity of line #2
:OUTPut:TTL3:LSENse <name>	Set polarity of line #3
:OUTPut:TTL4:LSENse <name>	Set polarity of line #4

Parameters

<name>	= AHIGh	Set polarity of specified line to active high.
	= ALOW	Set polarity of specified line to active low.

Formats

:outp:ttl:lsen <name>
:outp:ttl2:lsen <name>
:outp:ttl3:lsen <name>
:outp:ttl4:lsen <name>

Defaults

Power-up	No effect
*RST	No effect
:SYSTem:PRESet	No effect

Query

:LSENse?	Query polarity of specified line
Short-form formats:	:outp:ttl:lsen?
	:outp:ttl2:lsen?

:outp:ttl3:lsen?
:outp:ttl4:lsen?

Response message: AHIG or ALOW

Description

These commands are used to set the polarity of the digital output lines. When set for active high (AHIGh) polarity, the specified output line is true (ON) when the output level is high. The output line is false (OFF) when the output level is low.

When set for active low (ALOW) polarity, the output line is true (ON) when the output level is low. The output line is false (OFF) when the output level is high.

Programming example

```
10  OUTPUT 716; ":outp:ttl:lsen  alow; lsen?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the polarity of line #1 to active low.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the polarity of line #1 (ALOW).

4.18 :ROUTe subsystem

The commands in this subsystem are used to configure and control switching and are summarized in Table 4-11.

Table 4-11
ROUTe command summary

Command	Description	Paragraph
:ROUTe		
:CLOSe <list>	Path and command to close specified channel:	4.18.1
:STATe?	Query closed channel.	
:CLOSe? <list>	Query specified channels (1 = closed, 0 = open).	
:OPEN <list>	Open specified channel or all channels.	4.18.12
:OPEN:ALL	Open all channels.	4.18.3
:OPEN? <list>	Query specified channels (1 = open, 0 = closed).	
:SCAN	Command path to configure and control scan operations:	4.18.4
[:INTernal] <list>	Specify an internal scan list (2 to 10 channels).	
[:INTernal]?	Query the internal scan list.	
:FUNCtion <list>, <name>	Assign measurement function to specified channels.	
:FUNCtion? <list>	Query function for each specified channel.	
:EXTernal <list>	Specify an external scan list (2 to 80 channels).	
:EXTernal?	Query the external scan list.	
:FUNCtion <list>, <name>	Assign measurement function to specified channels.	
:FUNCtion? <list>	Query function for each specified channel.	
:RATio	Command path to configure ratio calculation:	
:FUNCtion <name>	Specify function for Ratio ('VOLTage:DC', 'RESistance' or 'FRESistance').	
:FUNCtion?	Query Ratio function.	
:RCHannel <list>	Specify reference channel (1 to 10).	
:RCHannel?	Query reference channel.	
:MCHannel <list>	Specify measure channel (1 to 10).	
:MCHannel?	Query measure channel.	
:DELTa	Command path to configure delta calculation:	
:FUNCtion <name>	Specify function for Delta ('VOLTage:DC', 'RESistance' or 'FRESistance').	
:FUNCtion?	Query Delta function.	
:RCHannel <list>	Specify reference channel (1 to 10).	
:RCHannel?	Query reference channel.	
:MCHannel <list>	Specify measure channel (1 to 10).	
:MCHannel?	Query measure channel.	
:LSELect <name>	Select scan operation: INTernal, EXTernal, RATio, DELTa, NONE.	
:LSELect?	Query scan operation.	

Notes:
1. Brackets [ ] are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets [ ] in the program message.
2. Angle brackets < > are used to indicate parameter type. Do not use angle brackets < > in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.18.1 :CLOSe <list>

:ROUTe:CLOSe <list> — Close specified channel

Parameter

<list> = (@ chanlist) — Specify channel to be closed

where; chanlist is the channel (1 to 10) to be closed

Format

:rout:clos <list>

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query

:CLOSe? <list>	Query specified channel.
Short-form format:	:rout:clos? <list>
	where; chanlist is the list of channels to be queried.
Response message:	1 (Specified channel is closed)
	0 (Specified channel is not closed)

Description

The :CLOSe <list> command is used to close a channel on the Model 2001-SCAN scanner card. Only one channel can be closed at a time. Thus, for this command, the chanlist must consist of only one channel. When this command is sent, any other closed channel will first open and then the specified channel will close. Sending more than one channel parameter will result in an error.

For example, to close channel 5, send the following command:

:rout:clos (@ 5)

The :CLOSe? <list> query command is used to determine the state (closed or not closed) of each channel specified by the list parameter. For this command, the chanlist can consist of multiple channels. The following examples demonstrate the various forms for expressing the channel list for this query command:

List =	(@ 2)	Single channel.
	(@ 2,4,6)	Multiple channels separated by commas (,).
	(@ 1:10)	Range of channels (1 though 10). Range limits separated by a colon (:).
	(@ 1:5,7)	Range entry and single entry separated by a comma.

After sending this query command and addressing the Model 2001 to talk, the values for the specified channels will be sent to the computer. A value of "1" indicates that the channel is closed, and a "0" indicates that the channel is not closed.

For example, assume channel 5 is closed and the following query command is sent:

:rout:clos? (@ 1:10)

After the addressing the Model 2001 to talk, the following response message will be sent to the computer:

0, 0, 0, 0, 1, 0, 0, 0, 0, 0

NOTE: Sending the :CLOSe or :CLOSe? command with the scanner card missing will result in an error.

Programming example

This example assumes that the Model 2001 SCAN is installed.

```
10  OUTPUT 716; ":rout:clos  (@ 10); clos? (@ 1:10)"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first closes channel 10, and the second queries all 10 channels.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of all 10 channels (0, 0, 0, 0, 0, 0, 0, 0, 0, 1).

STATe?

:ROUTe:CLOSe:STATe? Query closed channel.

Format

```
:rout:clos:stat?
```

Description

This query command is used to determine which (if any) channel on the Model 2001 SCAN is currently closed. After sending this command and addressing the Model 2001 to talk, the code identifying the closed channel will be sent to the computer. For example, if channel 10 is currently closed, the following channel list will be sent to the computer:

(@10)

If all channels are open, the following empty channel list will be sent:

(@)

Programming example

```
10  OUTPUT 716; ":rout:clos:stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Queries closed channels.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the closed channels.

4.18.2 :OPEN <list>

:ROUTe:OPEN <list>

Parameters

<list>	= (@ chanlist)	Specify channel to open
	= ALL	Open all channels
	where; chanlist = 1 to 10	

Format

```
:rout:open <list>
```

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query

:OPEN? <list> Query specified channel.
Short-form format: :rout:open? <list>
where; chanlist is the list of channels to be queried.
Response message: 1 (Specified channel is open)
0 (Specified channel is not open)

Description

The :OPEN <list> command is used to open a channel on the Model 2001-SCAN scanner card. Since only one channel can be closed, the chanlist for this command need only consist of one channel. An alternate way to open a closed channel is to simply use the ALL parameter. It will open whichever channel is currently closed.

The :OPEN? <list> query command is used to determine the state (opened or not opened) of each channel specified by the list parameter. For this command, the chanlist can consist of multiple channels. The following examples demonstrate the various forms for expressing the chanlist for this query command:

list = (@ 2) Single channel.
= (@ 2,4,6) Multiple channels separated by commas (,).
= (@ 1:10) Range of channels (1 though 10). Range limits separated by a colon (:).
= (@ 1:5,7) Range entry and single entry separated by a comma.

After sending this query command and addressing the Model 2001 to talk, the values for the specified channels will be sent to the computer. A value of "1" indicates that the channel is open, and a "0" indicates that the channel is not open.

For example, assume channel 5 is closed and the following query command is sent:

```
:rout:open? (@ 1:10)
```

After the addressing the Model 2001 to talk, the following response message will be sent to the computer:

```
1, 1, 1, 1, 0, 1, 1, 1, 1, 1
```

NOTE: Sending the :OPEN or :OPEN? command with the scanner card missing will result in an error.

Programming example

```
10 OUTPUT 716; ":rout:clos (@ 10); open? (@ 1:10)"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Two commands in this program message; the first closes channel 10, and the second queries all 10 channels.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of all 10 channels (1, 1, 1, 1, 1, 1, 1, 1, 1, 0).

4.18.3 :OPEN:ALL

:ROUTe:OPEN:ALL Open closed channel

Format

```
:rout:open:all
```

Description This action command is used to simply open any closed channel on the Model 2001 SCAN. Note that this command performs the same function as the :ROUTe:OPEN ALL command that was previously discussed.

Programming example

```
OUTPUT 716; ":rout:open:all"      ! Open all channels
```

4.18.4 :SCAN commands

[INTernal] <list>

:ROUTe:SCAN:[INTernal] <list> Define internal scan list

Parameter <list> = (@ scanlist)

where; scanlist is the specified list of channels (1 to 10) to be scanned.

Format :rout:scan <list>

Defaults

Power-up	Saved power-on setup
*RST	All 10 channels in scan list
:SYSTem:PRESet	All 10 channels in scan list

Query

:INTernal]?	Query programmed scan list
Short-form format:	:rout:scan?
Response message:	Currently programmed scan list. For example: (@ 1,2,3,4,5,6,7,8,9,10)

Description This command is used to define the scan list for the internal Model 2001-SCAN scanner card. The scan list can contain 2 to 10 channels. The following examples demonstrate the various forms for expressing a scan list:

list = (@ 2,4,6)	Channels separated by commas (,).
= (@ 1:8)	Range of channels (1 though 8). Range limits separated by a colon (:).
= (@ 1:5,7)	Range entry and single entry separated by a comma.

Only the channels specified in the scan list will be scanned. The order that channels are listed in the scan list is not important. The instrument will automatically re-arrange the scan list so that the channels are scanned in numeric order starting with the lowest channel number. Note that channels 5 and 10 of the Model 2001-SCAN are designed for high speed.

Important Note: When this command is sent, it will automatically select the internal scanner (see :ROUTe:SCAN:LSELect INTernal). This means that if the instrument is currently making measurements, the scan will start as soon as this command is used to define the scan list. To prevent this, you can first place the instrument in idle and then define the scan list. Sending the following two commands (in the order shown) will place the instrument in idle:

```
:INITiate:CONTinuous OFF
:ABORt
```

With the instrument in idle, you can then define the scan list without starting the scan. When ready, you can start the scan by sending either of the two following commands.

```
:INITiate or :INITiate:CONTinuous ON
```

Before performing an internal scan (Model 2001 SCAN), be sure that the instrument is appropriately configured for the measurements. The :SCAN[:INTernal]:FUNCtion command can be used to set each channel for a specific measurement function. Also, if you want the instrument to perform a particular number of scans, make sure to configure the Trigger Model appropriately (see Trigger Subsystem).

Programming example

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":init:cont  off; :abor"
30  OUTPUT 716; ":rout:scan  (@ 1,2,3,4,5)"
40  OUTPUT 716; ":arm:seq:lay2:coun  1"
50  OUTPUT 716; "trig:coun  5"
60  OUTPUT 716; ":init"
70  OUTPUT 716; ":syst:pres"
80  END
```

Line 10 Returns Model 2001 to :SYSTem:PREset defaults.
Line 20 Disables continuous initiation and places Model 2001 in idle state.
Line 30 Defines scan list.
Line 40 Programs scan layer of Trigger Model for one scan.
Line 50 Programs measure layer for five measurements.
Line 60 Perform a single scan of the five channels.
Line 70 Returns Model 2001 to :SYSTem:PREset defaults.

:EXTernal <list>

:ROUTe:SCAN:EXTernal <list> Define external scan list

Parameter

<list> = (@ scanlist)

where; scanlist is the specified list of external channels (1 to 80) to be scanned.

Format

:rout:scan:ext <list>

Defaults

Power-up	Saved power-on setup
*RST	All 80 channels in scan list
:SYSTem:PRESet	All 80 channels in scan list

Query

:EXTernal?	Query programmed scan list
Short-form format:	:rout:scan:ext?
Response message:	Currently programmed scanlist. For example: (@ 1,2,3,4,5,6,7,8,9,10)

Description

The Model 2001 can be set up to operate with an external switch system, such as the Keithley Model 7001. With both instruments properly configured, the Model 2001 can measure up to 80 channels that are switched by the external switching system. This command is used to define the external scan list for the Model 2001. This scan list simply programs a counter. When the scan list for the Model 2001 corresponds to the scan list for the external switch system, the Model 2001 can keep track of which channel is being measured. This allows specific measurement functions to be used for specific channels (see :EXTernal:FUNCtion).

The scan list can contain 2 to 80 channels. The following examples demonstrate the various forms for expressing a scan list:

List = (@ 2,4,6) Channels separated by commas (,).
= (@ 1:8) Range of channels (1 though 8). Range limits separated by a colon (:).
= (@ 1:5,7) Range entry and single entry separated by a comma.

Before performing an external scan, be sure that the Model 2001 is appropriately configured for the measurements. The :SCAN[:INTernal]:FUNCtion command can be used to set each channel for a specific measurement function. Also, if you want the instrument to perform a particular number of scans, make sure to configure the Trigger Model appropriately (see Trigger subsystem).

The external scan by the Model 2001 is enabled by the ROUTe:SCAN:LSELect EXTernal command.

Programming example

```
OUTPUT 716; ":rout:scan:ext  (@ 1:40)"  ! Define external scan list (1-40).
```

:FUNCtion <list>, <name>

:ROUTe:SCAN[:INTernal]:FUNCtion <list>, <name> Assign functions to channels; Internal
:ROUTe:SCAN:EXTernal:FUNCtion <list>, <name> Assign functions to channels; External

Parameter

<list> = (@ chanlist)

where; chanlist is the specified list of channels:

1 to 10 for Internal
1 to 80 for External

<name> = 'NONE'
= 'VOLTage:DC'
= 'VOLTage:AC'
= 'TEMPerature'
= 'FREQuency'
= 'RESistance'
= 'FRESistance'
= 'RJUNctionX' where; X = 1 to 5
= 'ALTernate[1]'
= 'CURRent:DC' (External only)
= 'CURRent:AC' (External only)

Formats

```
:rout:scan:func  <list>, <name>
:rout:scan:ext:func  <list>, <name>
```

Defaults

Power-up	Saved power-on setup
*RST	VOLTage:DC (all channels)
:SYSTem:PRESet	VOLTage:DC (all channels)

Query

:FUNCtion? <list> Query functions for specified channels

Short-form formats: :rout:scan:func? <list>

:rout:scan:ext:func? <list>

Response messages: NONE, VOLT:DC, VOLT:AC, TEMP, FREQ, RES, RJUNX, ALT, CURR:DC, and CURR:AC

Note: The function for each channel is separated by a comma.

Description

These commands are used to assign measurement functions for internal channels (e.g. Model 2001 SCAN) or external channels. You can assign a unique measurement function to each of channel. The function parameter specifies the measurement function for the channels specified by the channel list (chanlist).

The following examples demonstrate the various forms for expressing the channel list:

List = (@ 5)	Single channel.
= (@ 2,4,6)	Multiple channels separated by commas (,).
= (@ 1:10)	Range of channels (1 though 10). Range limits separated by a colon (:).
= (@ 1:5,7)	Range entry and single entry separated by a comma.

The function parameter specifies the measurement function for the channels listed in the chanlist. As a scan is being performed, the Model 2001 will select the specified measurement function for each channel in the scan.

Any measurement function, except current (ACI and DCI), can be used for internal scanning. Note that the Keithley Model 2001 SCAN scanner card cannot be used to make thermocouple temperature measurements. Any measurement function can be used for external scanning (assuming you are using the appropriate switching card).

With the NONE function parameter selected, the channels specified in the chanlist will be not be scanned. This will not change the defined scan list, it will simply cause the specified channels to be skipped.

With the ALTernate function parameter selected, the specified channels in the chanlist will be measured according to the saved alternate setup conditions. An alternate setup is saved using the [:SENSe[1]]:ALTernate SAVe command (see Sense subsystem).

Programming example

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":rout:scan:func  (@ 1,3,5,7), 'volt:dc'"
30  OUTPUT 716; ":rout:scan:func  (@ 2,4,6,8), 'res'"
40  OUTPUT 716; ":rout:scan:func  (@ 9,10), 'none'"
50  END
```

Line 10 :SYSTem:PREset defaults; all ten channels in scan list.

Line 20 Assigns the DCV function to channels 1, 3, 5 and 7.

Line 30 Assigns the Ω2 function to channels 2, 4, 6 and 8.

Line 40 Masks channels 9 and 10. These channels will not be scanned.

:RATio and :DELTa commands

:FUNCtion <name>

:ROUTe:SCAN:RATio:FUNCtion <name> Select function for Ratio
:ROUTe:SCAN:DELTa:FUNCtion <name> Select function for Delta

Parameters

<name> = 'VOLTage:DC' DCV function
= 'RESistance' Ω2 function
= 'FRESistance' Ω4 function

Formats

:rout:scan:rat:func <name>
:rout:scan:delt:func <name>

Defaults

Power-up	Saved power-on setup
*RST	'VOLTage:DC'
:SYSTem:PRESet	'VOLTage:DC'

Query

:FUNCtion?	Query function for specified calculation
Short-form formats:	:rout:scan:rat:func?
	:rout:scan:delt:func?
Response message:	"VOLT:DC", "RES" or "FRES"

Description

The :FUNCtion command is used to select the measurement function for the specified calculation (Ratio or Delta). Valid measurement functions include DCV, Ω2 and Ω4. Note that Ω4 (four-wire ohms) is only valid for reference and measure channels one through five (see :RCHannel and :MCHannel).

The function parameters are shown enclosed by single quotes. However, double quotes are also valid. Example:

'volt:dc' = "volt:dc"

Programming example

```
10  OUTPUT 716; ":rout:scan:rat:func 'res'; func?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects the Ω2 measurement function for the Ratio calculation and then queries the function.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the function for Ratio ("RES").

:RCHannel <list>

:ROUTe:SCAN:RATio:RCHannel <list> Specify reference channel for Ratio
:ROUTe:SCAN:DELTa:RCHannel <list> Specify reference channel for Delta

Parameter

<list> = (@ chanlist)

where; chanlist is a single channel number (1 to 10)

Formats

:rout:scan:rat:rch <list>
:rout:scan:delt:rch <list>

Defaults

Power-up	Saved power-on setup
*RST	Channel 5
:SYSTem:PRESet	Channel 5

Query

:RCHannel?	Query reference channel
Short-form formats:	:rout:scan:rat:rch?
	:rout:scan:delt:rch?
Response message:	(@ chanlist) where; chanlist = 1 to 10

Description

These commands are used to select the reference channel for the ratio and delta calculations. Note that channel 5 (which is the default) and channel 10 are the high speed solid state switches on the Model 2001 SCAN. Also note that channels 6 through 10 cannot be selected when the Ω4 function is selected for the specified calculation (see :FUNCtion).

When the ratio calculation is performed (see :SCAN:LSELect), it is calculated as follows:

$$\text{Ratio} = \frac{\text{Measure Channel}}{\text{Reference Channel}}$$

When the delta calculation is performed (see :SCAN:LSELect), it is calculated as follows:

Delta = Measure Channel - Reference Channel

Programming example

```
10  OUTPUT 716; ":rout:scan:rat:rch  (@1); rch?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects channel 1 as the reference channel, and then queries the reference channel.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the reference channel (@1).

:MCHannel <list>

:ROUTe:SCAN:RATio:MCHannel <list>	Specify measure channel for Ratio
:ROUTe:SCAN:DELTa:MCHannel <list>	Specify measure channel for Delta

Parameter

<list> = (@ chanlist)

where; chanlist is a single channel number (1 to 10)

Formats

:rout:scan:rat:mch <list>
:rout:scan:delt:mch <list>

Defaults

Power-up	Saved power-on setup
*RST	Channel 10
:SYSTem:PRESet	Channel 10

Query

:MCHannel?	Query measure channel
Short-form formats:	:rout:scan:rat:mch?
	:rout:scan:delt:mch?
Response message:	(@ chanlist) where; chanlist = 1 to 10

Description

These commands are used to select the measure channel for the ratio and delta calculations. Note that channel 5 and channel 10 (which is the default) are the high speed solid state switches on the Model 2001 SCAN. Also note that channels 6 through 10 cannot be selected when the Ω4 function is selected for the specified calculation (see :FUNCtion).

When the ratio calculation is performed (see :SCAN:LSELect), it is calculated as follows:

$$\text{Ratio} = \frac{\text{Measure Channel}}{\text{Reference Channel}}$$

When the delta calculation is performed (see :SCAN:LSELect), it is calculated as follows:

Delta = Measure Channel - Reference Channel

Programming example

```
10  OUTPUT 716; ":rout:scan:rat:mch  (@2); mch?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10	Selects channel 2 as the measure channel, and then queries the measure channel.
Line 20	Addresses the Model 2001 to talk.
Line 30	Displays the reference channel (@2).

:LSELect <name>

:ROUTe:SCAN:LSELect <name> Perform specified scan operation

Parameters

<name>	= INTernal	Enable scan for internal scanner card
	= EXTernal	Enable scan for external scanner card
	= RATio	Perform ratio calculation
	= DELTa	Perform delta calculation
	= NONE	Disable all scan operations

Format

:rout:scan:lsel <name>

Defaults

Power-up	Saved power-on setup
*RST	NONE
:SYSTem:PRESet	NONE

Query

:LSELect?	Query scan operation
Short-form format:	:rout:scan:lsel?
Response message:	INT, EXT, RAT, DELT or NONE

Description

This command is used to select and perform the desired scan operation. When INTernal is selected, the Model 2001 will scan the channels of the internal switching card according to how the scan is configured (see :ROUTe:SCAN[:INTernal]). EXTernal is used to measure channels that are controlled by an external switch system. When EXTernal is selected, the Model 2001 will scan the external scan list (see :SCAN:EXTernal).

With RATio or DELTa selected, the Model 2001 will perform the appropriate math calculation using the specified reference channel and measure channel (see :RCHannel and :MCHannel).

The NONE selection disables all operations associated with a scan.

Programming example

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":init:cont  off"
30  OUTPUT 716; ":arm:seq:lay2:coun  5"
40  OUTPUT 716; ":trig:coun  10"
50  OUTPUT 716; ":rout:scan:lsel  int"
60  END
```

Line 10 Sets Model 2001 to :SYSTem:PRESet defaults.

Line 20 Disables continuous initiation.

Line 30 Sets scan count to five.

Line 40 Sets measure count to 10.

Line 50 Selects and starts an internal scan. The 10 channel scan list will be scanned five times.

4.19 Sense subsystems

The Sense subsystems are used to configure and control the measurement functions (Sense 1) and to read the digital input port (Sense 2). The commands for the Sense subsystems are summarized in Table 4-12.

Table 4-12
SENSe command summary

Command	Description	Paragraph
[:SENSe[1]]		4.19.1
:ALTernate[1]	Path to control an Alternate setup.	4.19.2
:SAVE	Save current setup as Alternate setup.	
:RECall	Return instrument to Alternate setup.	
:FUNCtion <name>	Select measurement function: 'VOLTage:AC', 'VOLTage:DC', 'RESistance', 'FRESistance', 'CURRent:AC', 'CURRent:DC', 'FREQuency', 'TEMPerature'	4.19.3
:FUNCtion?	Query function.	
:DATA	Path to select reading type:	4.19.4
[:LATest]?	Query the latest reading.	
:FRESh?	Query a fresh reading.	
:CURRent:AC	Path to configure AC current.	4.19.5
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	4.19.6
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	4.19.7
:COUPling AC|DC	Specify input coupling.	4.19.8
:COUPling?	Query input coupling.	
:RANGe	Path to configure measurement range:	
[:UPPer] <n>	Select range (0 to +2.1).	
[:UPPer]?	Query range.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.	
:AUTO ONCE	Set range based on present input signal.	
:ULIMit <n>	Specify upper limit for auto range (0 to +2.1).	
:ULIMit?	Query upper limit.	
:LLIMit <n>	Specify lower limit for auto range (0 to +2.1).	
:LLIMit?	Query lower limit.	
:AUTO?	Query auto range.	
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 to 8).	4.19.10
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:CURRent AC		
:AVERage	Path to configure and control the filter.	4.19.11
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
:ADVanced	Path to configure and control advanced filter.	
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).	
:NTOLerance?	Query noise tolerance level.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.	
[:STATe]?	Query state of advanced filter.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:DETector	Path to select function:	4.19.13
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage.	
[:FUNCtion]?	Query detector function.	
:CURRent[:DC]	Path to configure DC current.	
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	4.19.5
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).	4.19.6
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC.	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	
:RANGe	Path to configure measurement range:	4.19.8
[:UPPer] <n>	Select range (0 to 2.1).	
[:UPPer]?	Query range.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.	
:AUTO ONCE	Set range based on present input signal.	
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1).	
:ULIMit?	Query upper limit.	
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1).	
:LLIMit?	Query lower limit.	
:AUTO?	Query auto range.	
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 to 8).	4.19.10
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:CURRent[:DC]		
:AVERage	Path to configure and control the filter.	4.19.11
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
:ADVanced	Path to configure and control advanced filter.	
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).	
:NTOLerance?	Query noise tolerance level.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.	
[:STATe]?	Query state of advanced filter.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:METHod <name>	Select measurement technique: NORMal, ICIRcuit.	4.19.15
:METHod?	Query method.	
:VOLTage:AC	Path to configure AC voltage.	
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	4.19.5
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).	4.19.6
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC.	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	
:COUPling AC|DC	Specify input coupling.	4.19.7
:COUPling?	Query input coupling.	
:RANGe	Path to configure measurement range:	4.19.8
[:UPPer] <n>	Select range (0 to +775).	
[:UPPer]?	Query range.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.	
:AUTO ONCE	Set range based on present input signal.	
:ULIMit <n>	Specify upper limit for auto range (0 to +775).	
:ULIMit?	Query upper limit.	
:LLIMit <n>	Specify lower limit for auto range (0 to +775).	
:LLIMit?	Query lower limit.	
:AUTO?	Query auto range.	
:REFerence <n>	Specify reference (REL) value (-775 to +775).	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:VOLTage:AC		
:DIGits <n>	Specify measurement resolution (4 to 8).	4.19.10
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	
:AVERage	Path to configure and control the filter.	4.19.11
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
:ADVanced	Path to configure and control advanced filter.	
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).	
:NTOLerance?	Query noise tolerance level.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.	
[:STATe]?	Query state of advanced filter.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:DETector	Path to select function:	4.19.13
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage PEAK, LFRMs, NPeak, PPeak.	
[:FUNCtion]?	Query detector function.	
:PWINdow <n>	Specify window in seconds (0.1 to 9.9).	4.19.14
:PWINdow?	Query peak spike detection window.	
:VOLTage[:DC]	Path to configure DC voltage:	
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	4.19.5
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	
:NPLCycles <n>	Specify integration rate (number of line cycles; (0.01 to 10).	4.19.6
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC.	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	
:RANGe	Path to configure measurement range:	4.19.8
[:UPPer] <n>	Select range (0 to 1100).	
[:UPPer]?	Query range.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.	
:AUTO ONCE	Set range based on present input signal.	
:ULIMit <n>	Specify upper limit for auto range (0 to 1100).	
:ULIMit?	Query upper limit.	
:LLIMit <n>	Specify lower limit for auto range (0 to 1100).	
:LLIMit?	Query lower limit.	
:AUTO?	Query auto range.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:VOLTage[:DC]		
:REFerence <n>	Specify reference (REL) value (-1100 to +1100).	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 to 8).	4.19.10
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	
:AVERage	Path to configure and control the filter.	4.19.11
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
:ADVanced	Path to configure and control advanced filter.	
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).	
:NTOLerance?	Query noise tolerance level.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.	
[:STATe]?	Query state of advanced filter.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:FILTer	Path to control the analog filter:	4.19.12
[:LPASs]		
[:STATe] <b>	Enable or disable the analog filter.	
[:STATe]?	Query state of analog filter.	
:RESistance	Path to configure resistance:	
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	4.19.5
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).	4.19.6
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC.	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	
:RANGe	Path to configure measurement range:	4.19.8
[:UPPer] <n>	Select range (0 to 1.05e9).	
[:UPPer]?	Query range.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.	
:AUTO ONCE	Set range based on present input signal.	
:ULIMit <n>	Specify upper limit for auto range (0 to 1.05e9).	
:ULIMit?	Query upper limit.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:RESistance		
:AUTO ONCE		
:LLIMit <n>	Specify lower limit for auto range (0 to 1.05e9).	4.19.9
:LLIMit?	Query lower limit.	
:AUTO?	Query auto range.	
:REFerence <n>	Specify reference (REL) value (-1.05e9 to +1.05e9).	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	4.19.10
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 to 8).	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	4.19.11
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	
:AVERage	Path to configure and control the filter.	
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
:ADVanced	Path to configure and control advanced filter.	
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).	
:NTOLerance?	Query noise tolerance level.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.	
[:STATe]?	Query state of advanced filter.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	4.19.23
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.	
:OCOMpensated?	Query Offset Compensation.	
:FRESistance	Path to configure four-wire resistance:	
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	4.19.5
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).	4.19.6
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC.	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	
:RANGe	Path to configure measurement range:	4.19.8
[:UPPer] <n>	Select range (0 to 2.1e5).	
[:UPPer]?	Query range.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:FRESistance		
:AUTO ONCE	Set range based on present input signal.	
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1e5).	
:ULIMit?	Query upper limit.	
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1e5).	
:LLIMit?	Query lower limit.	
:AUTO?	Query auto range.	
:REFerence <n>	Specify reference (REL) value (-2.1e5 to +2.1e5).	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 to 8).	4.19.10
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	
:AVERage	Path to configure and control the filter.	4.19.11
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
:ADVanced	Path to configure and control advanced filter.	
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).	
:NTOLerance?	Query noise tolerance level.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.	
[:STATe]?	Query state of advanced filter.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.	4.19.23
:OCOMpensated?	Query Offset Compensation.	
:FREQuency	Path to configure frequency:	
:COUPling AC|DC	Specify input coupling.	4.19.7
:COUPling?	Query input coupling.	
:REFerence <n>	Specify reference (REL) value (0 to 15e6).	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 or 5).	4.19.10
:DIGits?	Query resolution.	
:SOURce <name>	Select source: CURRent, VOLTage.	4.19.16
:SOURce?	Query source.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:FREQuency		
:THReshold	Path to configure threshold:	4.19.17
:CURRent	Path to set current threshold:	
:RANGe <n>	Specify range (0 to 1).	
:RANGe?	Query range.	
:LEVel <n>	Specify threshold level.	
:LEVel?	Query threshold level.	
:VOLTage	Path to set voltage threshold:	
:RANGe <n>	Specify range (0 to 1000).	
:RANGe?	Query range.	
:LEVel <n>	Specify threshold level.	
:LEVel?	Query threshold level.	
:TTL	Set threshold to TTL level.	
:TEMPerature	Path to configure four-wire resistance:	
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).	4.19.5
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.	
:AUTO ONCE	Enable and then disable auto aperture.	
:AUTO?	Query auto aperture (0 or 1).	
:APERture?	Query aperture (integration rate).	
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).	4.19.6
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.	
:AUTO ONCE	Enable and then disable auto NPLC.	
:AUTO?	Query auto line cycle integration (0 or 1).	
:NPLCycles?	Query line cycle integration rate.	
:REFerence <n>	Specify reference (REL) value.	4.19.9
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.	
:STATe?	Query state of REL (0 or 1).	
:ACQuire	Use input signal as reference.	
:REFerence?	Query reference (REL) value.	
:DIGits <n>	Specify measurement resolution (4 to 7).	4.19.10
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.	
:AUTO ONCE	Enable and then disable auto resolution.	
:AUTO?	Query auto resolution (0 or 1).	
:DIGits?	Query resolution.	
:AVERage	Path to configure and control the filter.	
:TCONtrol <name>	Select filter type: MOVing, REPeat.	
:TCONtrol?	Query filter type.	
:COUNt <n>	Specify filter count (1 to 100).	
:COUNt?	Query filter count.	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.	
[:STATe]?	Query state of digital filter.	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.	
:AUTO ONCE	Enable and then disable auto filter.	
:AUTO?	Query auto filter.	
:TRANsducer <name>	Select transducer: RTD, FRTD, TCouple.	4.19.18
:TRANsducer?	Query transducer.	

Table 4-12(cont.)
SENSe command summary

Command	Description	Paragraph
:TEMPerature		
:RTD	Path to configure RTD measurements:	4.19.19
:TYPE <name>	Select RTD parameters: PT385, PT3916, USER, SPRTD	
:TYPE?	Query RTD type.	
:ALPHa <NRf>	Specify constant for USER type (0 to 0.01).	
:ALPHa?	Query alpha.	
:BETA <NRf>	Specify constant for USER type (0 to 1).	
:BETA?	Query beta.	
:DELTa <NRf>	Specify constant for USER type (0 to 5).	
:DELTa?	Query delta.	
:RZERo <NRf>	Specify constant for USER type (0 to 1000).	
:RZERo?	Query rzero.	
:SPRTD	Select SPRTD type parameters.	
:RZERo <NRf>	Set sensor 0°C R value.	
:A4 <NRf>	Set A4 coefficient.	
:B4 <NRf>	Set B4 coefficient.	
:A7 <NRf>	Set A7 coefficient.	
:B7 <NRf>	Set B7 coefficient.	
:C7 <NRf>	Set C7 coefficient.	
:TCouple	Path to configure TC measurements:	
:TYPE <name>	Select thermocouple type: J, T, K, E, R, S, B, N.	4.19.20
:TYPE?	Query TC type.	
:RJUNctionX	Path to configure reference junctions (X = 1 to 5).	4.19.21
:RSELect <name>	Select reference type: SIMulated, REAL.	
:RSELect?	Query reference type.	
:SIMulated <n>	Specify simulated temperature.	
:SIMulated?	Query simulated temperature.	
:REAL	Command path to specify "real" reference junction	4.19.22
:TCOefficient <n>	Specify TC	
:TCOefficient?	Query TC	
:OFFSet <n>	Specify voltage offset at 0°C.	
:OFFSet?	Query voltage offset.	
:ACQuire	Update reference temperature.	
:SENSe2		4.19.24
:TTL[1]	Path to read digital input port:	
:DATA?	Query (read) the digital input port.	

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.19.1 [:SENSe[1]] subsystem

This Sense 1 Subsystem is used to configure and control the measurement functions of the Model 2001. Keep in mind that a function does not have to be selected in order to program its various configurations. When the function is later selected, it will assume the programmed states.

4.19.2 :ALTernate[1] commands

:SAVE

[:SENSe[1]]:ALTernate[1]:SAVE Save Alternate setup.

Format :alt:save

Defaults

Power-up	Saved Alternate setup lost
*RST	Saved Alternate setup lost
:SYSTem:PRESet	Saved Alternate setup lost

Description This command is used to save the current instrument setup as the Alternate setup. The instrument can be returned to the Alternate setup by using the :ALTernate[1]:RECall command.

An Alternate setup can be used as the function parameter for a scan (see :ROUTe :SCAN).

Programming example

```
OUTPUT 716; ":alt:save"        ! Save current setup as the Alternate setup.
```

:RECall

:SENSe[1]:ALTernate[1]:RECall Return to Alternate setup.

Description This command is used to return the instrument to an Alternate setup (see :ALTernate[1]:SAVE). If there is no Alternate setup currently saved, this command will simply be a No-Op (no operation).

Programming example

```
OUTPUT 716; ":alt:rec"         ! Recall Alternate setup.
```

4.19.3 :FUNCtion <name>

[:SENSe[1]]:FUNCtion <name> Select measurement function.

Parameters

<name>	= 'VOLTage:AC'	Select ACV
	= 'VOLTage:DC'	Select DCV
	= 'RESistance'	Select Ω2
	= 'FRESistance'	Select Ω4
	= 'CURRent:AC'	Select ACI
	= 'CURRent:DC'	Select DCI
	= 'FREQuency'	Select FREQ
	= 'TEMPerature'	Select TEMP

Format :func <name>

Defaults

Power-up	Saved power-on setup condition
*RST	'VOLTage:DC'
:SYSTem:PRESet	'VOLTage:DC'

Query

:FUNCtion? Query currently programmed function.
Short-form format: :func?
Response messages: Function name

Description

The :FUNCtion command is used to select the measurement function of the instrument. Note that parameter names are enclosed in single quotes (‘). However, double quotes (“) can instead be used. For example:

:func ‘volt:dc’ = :func “volt:dc”

Each measurement function “remembers” its own unique setup configuration, such as range, speed, resolution, filter and rel. This eliminates the need to re-program setup conditions every time you switch from one function to another.

Programming example

```
10 OUTPUT 716; ":func 'volt:ac'; func?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Two commands in this program message, the first command selects ACV, and second command queries the function.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays (on CRT) the function name (VOLTS:AC).

4.19.4 DATA Commands

[:LATest]?

[:SENSe[1]]:DATA[LATest]? Request latest reading.

Description

This query command is used to read the latest instrument reading. This command returns the “raw” reading or a reading that is the result of the Reference (REL from the front panel) operation. For example, if a reference value of 1.0 is established, the reading returned by this command is the “raw” reading minus 1.0. Calculated (MATH) readings cannot be read with this command (see the CALCulate Subsystem to read math calculations).

The reading is returned in exponent form. For example, a 10V DC reading is displayed on the CRT as follows:

+1.000000E+01

Notice that the measurement function is not included in the response message. Thus, you may want to perform a function query (see previous command) after a reading query.

Programming example

```
10 OUTPUT 716; ":data?; func?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Requests latest reading and queries function.
Line 20 Addresses 2001 to talk.
Line 30 Displays the reading and function.

:FRESh

[:SENSe[1]]:DATA:FRESh — Request new reading.

Description This query command is used to return a new (fresh) reading. This command will not return the same reading more than once. If sent again, this command will wait until a new reading is triggered and available.

Programming example

```
10  OUTPUT 716; ":data:fresh?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Requests fresh reading.
Line 20 Addresses 2001 to talk.
Line 30 Displays the reading.

4.19.5 :APERture <n>

[:SENSe[1]]:CURRent:AC:APERture <n>	Set aperture for ACI
[:SENSe[1]]:CURRent[:DC]:APERture <n>	Set aperture for DCI
[:SENSe[1]]:VOLTage:AC:APERture <n>	Set aperture for ACV
[:SENSe[1]]:VOLTage[:DC]:APERture <n>	Set aperture for DCV
[:SENSe[1]]:RESistance:APERture <n>	Set aperture for Ω2
[:SENSe[1]]:FRESistance:APERture <n>	Set aperture for Ω4
[:SENSe[1]]:TEMPerature:APERture <n>	Set aperture for TEMP

Parameters

<n>	= 166.6666666667e-6 to 200e-3	Integration period in seconds
	= DEFault	Power line cycle integration: 16.67msec for 60Hz power line 20msec for 50Hz and 400Hz power line
	= MINimum	166.6666666667e-6sec
	= MAXimum	200e-3sec

where; 166.6666666667e-6 = 166.6666666667µsec.
200e-3 = 166.6666666667msec.

Formats

:curr:ac:aper <n>	:curr[:dc]:aper <n>
:volt:ac:aper <n>	:volt[:dc]:aper <n>
:res:aper <n>	:fres:aper <n>
:temp:aper <n>	

Defaults

Power-up	Saved power-on setup
*RST	Power line cycle integration: 16.67msec for 60Hz power line 20msec for 50Hz and 400Hz power line
:SYSTem:PRESet	Same as *RST

Query

:APERture?	Query programmed aperture value.
:APERture? DEFault	Query *RST default aperture value.
:APERture? MINimum	Query minimum aperture value.
:APERture? MAXimum	Query maximum aperture value.

Short-form formats:

:curr:ac:aper?	:curr[:dc]:aper?
:curr:ac:aper? xxx	:curr[:dc]:aper? xxx
:volt:ac:aper?	:volt[:dc]:aper?
:volt:ac:aper? xxx	:volt[:dc]:aper? xxx
:res:aper?	:fres:aper?
:res:aper? xxx	:fres:aper? xxx
:temp:aper?	
:temp:aper? xxx	

where; xxx = def, min or max

Response message: 166.6666666667e-6 to 200e-3 seconds

Description

These commands are used to set the integration period for the measurement functions. The integration period for a triggered reading (measurement) can be expressed as aperture (seconds per integration). In general, a short integration period provides a fast reading rate, while a long integration period provides better accuracy. Typically, the selected integration period is based on a compromise between speed and accuracy. Any triggers received while the instrument is processing a reading will be ignored.

An alternate way to set the integration period is by basing it on the number of power line cycles (see :NPLCycles command). If the number of power line cycles per integration (NPLC) is already known, aperture can be calculated as follows:

$$\text{Aperture} = \frac{\text{NPLC}}{\text{f}}$$

where; Aperture is the integration rate in seconds per integration.
NPLC is the number of power line cycles per integration.
f is the power line frequency. (Note: For 400Hz line power, use 50Hz to calculate aperture).

Keep in mind that when the integration period is set using the :APERture command, the value for the :NPLCycle command will change accordingly to reflect the new integration period. Conversely, if the integration period is set using the :NPLCycle command, the value for the :APERture command will change accordingly.

On power-up, the instrument will use the NPLC value to determine the integration period. Thus, if using a different power line frequency, NPLC will remain the same, but aperture may change.

Note: If line synchronization is enabled (see:LSYNc command in SYSTem subsystem), the integration period will not start until the beginning of the next power line cycle. For example, if a reading is triggered at the positive peak of a power line cycle, the integration period will not start until that power line cycle is completed. The integration period starts when the positive-going sine wave crosses zero volts. See paragraph 3.12 for more details.

Programming example

```
10  OUTPUT 716; ":curr:ac:aper  16.67e-3; aper?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets aperture for ACI and then queries the programmed aperture.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed aperture value.

:AUTO <b>|ONCE

[:SENSe[1]]:CURRent:AC:APERture:AUTO <b>|ONCE	Control auto aperture for ACI
[:SENSe[1]]:CURRent[:DC]:APERture:AUTO <b>|ONCE	Control auto aperture for DCI
[:SENSe[1]]:VOLTage:AC:APERture:AUTO <b>|ONCE	Control auto aperture for ACV
[:SENSe[1]]:VOLTage[:DC]:APERture:AUTO <b>|ONCE	Control auto aperture for DCV
[:SENSe[1]]:RESistance:APERture:AUTO <b>|ONCE	Control auto aperture for Ω2
[:SENSe[1]]:FRESistance:APERture:AUTO <b>|ONCE	Control auto aperture for Ω4
[:SENSe[1]]:TEMPerature:APERture:AUTO <b>|ONCE	Control auto aperture for TEMP

Parameters

<b>	= 1 or ON	Enable auto aperture
	= 0 or OFF	Disable auto aperture
ONCE		Enable and then disable auto aperture

Formats

:curr:ac:aper:auto <b>	:curr[:dc]:aper:auto <b>
:curr:ac:aper:auto ONCE	:curr[:dc]:aper:auto ONCE
:volt:ac:aper:auto <b>	:volt[:dc]:aper:auto <b>
:volt:ac:aper:auto ONCE	:volt[:dc]:aper:auto ONCE
:res:aper:auto <b>	:fres:aper:auto <b>
:res:aper:auto ONCE	:fres:aper:auto ONCE
:temp:aper:auto <b>	
:temp:aper:auto ONCE	

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:AUTO?	Query state of auto aperture.
Short-form formats:	:curr:ac:aper:auto?
	:curr:dc:aper:auto?
	:volt:ac:aper:auto?
	:volt:dc:aper:auto?
	:res:aper:auto?
	:fres:aper:auto?
	:temp:aper:auto?
Response message:	0 (off) or 1 (on)

Description

These commands are used to enable or disable auto aperture for for the specified measurement function. With auto aperture enabled, the instrument will automatically select the aperture value to optimize the measurement.

When auto aperture is enabled for the TEMP function, the instrument will select an aperture value of 16.67msec for the 60Hz power line (20msec for the 50Hz or 400Hz power line). The aperture values selected by the instrument for the other measurement functions are summarized in Tables 4-13 through 4-16.

The ONCE parameter is analogous to a momentary toggle switch. When :AUTO ONCE is sent, auto aperture will turn on momentarily and then disable. While enabled it will automatically select the appropriate value as summarized in the tables. When auto aperture disables, the aperture will remain at the selected value.

:APERture:AUTO is coupled to the command that manually sets the aperture value (:APERture <n>). When auto aperture is enabled, the parameter value for :APERture <n> changes to the automatically selected aperture value. Thus, when auto aperture is disabled, the aperture will remain at the automatically selected value.

Auto aperture is also coupled to auto NPLC. Enabling or disabling auto aperture also enables or disables auto NPLC. Also, a valid NPLC value sent using the :NPLC command will disable auto aperture.

Table 4-13
Auto aperture; ACI

Resolution	Aperture value (Auto aperture enabled)
6½ digits*	166.67msec (60Hz power line cycle) 200msec (50Hz and 400Hz)
5½ digits*	333.33µsec (60Hz) 400µsec (50Hz and 400Hz)
4½ digits*	166.67µsec (60Hz) 200µsec (50Hz and 400Hz)
Auto resolution enabled	

* Auto resolution disabled.

Table 4-14
Auto aperture; DCI

Measurement type	Resolution	Aperture value (Auto aperture enabled)
Normal	7½ digits*	33.33msec (60Hz power line) 40msec (50Hz and 400Hz)
Normal	6½ digits*	3.33msec (60Hz) 4msec (50Hz and 400Hz)
Normal	5½ digits*	333.33µsec (60Hz) 400µsec (50Hz and 400Hz)
Normal	4½ digits*	166.67µsec (60Hz) 200µsec (50Hz and 400Hz)
Normal	Auto resolution enabled	16.67msec (60Hz) 20msec (50Hz and 400Hz)
In-circuit	5½ digits*	Any

* Auto resolution disabled.

Table 4-15
Auto aperture; ACV

Measurement type	Resolution	Aperture value (Auto Aperture Enabled)
RMS, average	7½ digits*	166.67msec (60Hz) 200msec (50Hz and 400Hz)
RMS, average	6½ digits*	166.67msec (60Hz) 200msec (50Hz and 400Hz)
RMS, average	5½ digits*	333.33µsec (60Hz) 400µsec (50Hz and 400Hz)
RMS, average	4½ digits*	166.67µsec (60Hz) 200µsec (50Hz and 400Hz)
RMS, average	3½ digits*	166.67µsec (60Hz) 200µsec (50Hz and 400Hz)
RMS, average	Auto resolution enabled	16.67msec (60Hz) 20msec (50Hz and 400Hz)
Low freq RMS	Any*	Selection not used**
Low freq RMS	Auto resolution enabled	Selection not used**
Peak, positive and negative spikes	Any*	Selection not used**
Peak, positive and negative spikes	Auto resolution enabled	Selection not used**

* Auto resolution disabled.
** The currently selected aperture value is not used for this measurement type.

Table 4-16
Auto aperture; DCV, Ω2 and Ω4

Resolution	Aperture value (Auto aperture enabled)
7½ digits*	33.33msec (60Hz) 40msec (50Hz and 400Hz)
6½ digits*	3.33msec (60Hz) 4msec (50Hz and 400Hz)
5½ digits*	333.33µsec (60Hz) 400µsec (50Hz and 400Hz)
4½ digits*	166.67µsec (60Hz) 200µsec (50Hz and 400Hz)
3½ digits*	166.67µsec (60Hz) 200µsec (50Hz and 400Hz)
Auto resolution enabled	16.67msec (60Hz) 20msec (50Hz and 400Hz)

* Auto resolution disabled.

Programming example

```
10  OUTPUT 716; ":curr:ac:aper:auto  on; auto?"
20  ENTER 716; A$
30  PRINT A
40  END
```

Line 10 Enables auto aperture and then queries auto aperture.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of auto aperture (1).

4.19.6 :NPLCycles <n>

[:SENSe[1]:CURRent:AC:NPLCycles <n>	Set NPLC for ACI
[:SENSe[1]]:CURRent[:DC]:NPLCycles <n>	Set NPLC for DCI
[:SENSe[1]]:VOLTage:AC:NPLCycles <n>	Set NPLC for ACV
[:SENSe[1]]:VOLTage[:DC]:NPLCycles <n>	Set NPLC for DCV
[:SENSe[1]]:RESistance:NPLCycles <n>	Set NPLC for Ω2
[:SENSe[1]]:FRESistance:NPLCycles <n>	Set NPLC for Ω4
[:SENSe[1]]:TEMPerature:NPLCycles <n>	Set NPLC for TEMP

Parameters

<n>	= 0.01 to 10	Power line cycles (n) per integration
	= DEFault	1
	= MINimum	0.01
	= MAXimum	10

Formats

:curr:ac:nplc <n> :curr[:dc]:nplc <n>
:volt:ac:nplc <n> :volt[:dc]:nplc <n>
:res:nplc <n> :fres:nplc <n>
:temp:nplc <n>

Defaults

Power-up	Saved power-on setup
*RST	1
:SYSTem:PRESet	1

Query

:NPLCycles?	Query programmed NPLC value
:NPLCycles? DEFault	Query *RST default value
:NPLCycles? MINimum	Query minimum NPLC value
:NPLCycles? MAXimum	Query maximum NPLC value

Short-form formats:

:curr:ac:nplc?	:curr[:dc]:nplc?
:curr:ac:nplc? xxx	:curr[:dc]:nplc? xxx
:volt:ac:nplc?	:volt[:dc]:nplc?
:volt:ac:nplc? xxx	:volt[:dc]:nplc? xxx
:res:nplc?	:fres:nplc?
:res:nplc? xxx	:fres:nplc? xxx
:temp:nplc?	
:temp:nplc? xxx	

where; xxx = def, min or max

Response message: 0.01 to 10

Description

These commands are used to set the integration period for the measurement functions. The integration period for a triggered reading (measurement) can be expressed by basing it on the power line frequency. These commands and parameters are used to specify the number of power line cycles (NPLC) per integration. For example, with :NPLCycles programmed for n = 0.5, the integration period for each triggered reading will take one-half of a power line cycle. Any triggers received while the instrument is processing a reading will be ignored.

In general, a short integration period (small NPLC) provides a fast reading rate, while a long integration period (large NPLC) provides better accuracy. Typically, the selected integration period is based on a compromise between speed and accuracy.

An alternate way to set the integration rate is by programming the aperture, which is seconds per integration (see :APERture command). If the aperture is already known, the following equation can be used to determine the number of power line cycles per integration (NPLC):

NPLC = Aperture × f

where; NPLC is the number of power line cycles per integration.
Aperture is the integration period in seconds per integration.
f is the power line frequency (Note: For 400Hz line power, use 50Hz to calculate aperture).

Keep in mind that when the integration period is set using the :NPLCycles command, the time value for the :APERture command will change accordingly to reflect the new integration rate. Conversely, if the integration period is set using the :APERture command, the value for the :NPLCycle command will change accordingly.

On power-up, the instrument will use the NPLC value to determine the integration period. Thus, if using a different power line frequency, the NPLC value will remain the same, but the aperture time value may change.

Note: If line synchronization is enabled (see:LSYNc command in SYSTem subsystem), the integration period will not start until the beginning of the next power line cycle. For example, if a reading is triggered at the positive peak of a power line cycle, the integration period will not start until that power line cycle is completed. The integration period starts when the positive-going sine wave crosses zero volts. See paragraph 3.12 for more details.

Programming example

```
10  OUTPUT 716; ":curr:ac:nplc  2; nplc?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the integration rate for two cycles per measurement, and then queries the NPLC value.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed NPLC value (2).

:AUTO <b>|ONCE

[:SENSe[1]]:CURRent:AC:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for ACI
[:SENSe[1]]:CURRent[:DC]:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for DCI
[:SENSe[1]]:VOLTage:AC:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for ACV
[:SENSe[1]]:VOLTage[:DC]:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for DCV
[:SENSe[1]]:RESistance:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for Ω2
[:SENSe[1]]:FRESistance:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for Ω4
[:SENSe[1]]:TEMPerature:NPLCycles:AUTO <b>|ONCE	Control auto NPLC for TEMP

Parameters

<b>	= 1 or ON	Enable auto NPLC
	= 0 or OFF	Disable auto NPLC
ONCE		Enable and then disable auto NPLC

Formats

```
:curr:ac:nplc:auto <b>          :curr[:dc]:nplc:auto <b>
:curr:ac:nplc:auto ONCE         :curr[:dc]:nplc:auto ONCE
:volt:ac:nplc:auto <b>          :volt[:dc]:nplc:auto <b>
:volt:ac:nplc:auto ONCE         :volt[:dc]:nplc:auto ONCE
:res:nplc:auto <b>              :fres:nplc:auto <b>
:res:nplc:auto ONCE             :fres:nplc:auto ONCE
:temp:nplc:auto <b>
:temp:nplc:auto ONCE
```

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:AUTO?	Query state of auto NPLC
Short-form formats:	:curr:ac:nplc:auto?
	:curr[:dc]:nplc:auto?
	:volt:ac:nplc:auto?
	:volt[:dc]:nplc:auto?
	:res:nplc:auto?
	:fres:nplc:auto?
	:temp:nplc:auto?
Response message:	0 (off) or 1 (on)

Description

These commands are used to enable or disable auto NPLC for for the specified measurement function. With auto NPLC enabled, the instrument will automatically select the NPLC value to optimize the measurement.

When auto NPLC is enabled for the TEMP function, the instrument will select an NPLC value of 1. The NPLC values selected by the instrument for the other measurement functions are summarized in Tables 4-17 through 4-20.

The ONCE parameter is analogous to a momentary toggle switch. When :AUTO ONCE is sent, auto NPLC will turn on momentarily and then disable. While enabled it will automatically select the appropriate value as summarized in the tables. When auto NPLC disables, NPLC will remain at the selected value.

:NPLC:AUTO is coupled to the command that manually sets the NPLC value (:NPLC <n>). When auto NPLC is enabled, the parameter value for :NPLC <n> changes to the automatically selected NPLC value. Thus, when auto NPLC is disabled, the NPLC will remain at the automatically selected value.

Auto NPLC is also coupled to auto aperture. Enabling or disabling auto NPLC also enables or disables auto Aperture. Also, a valid aperture value sent using the :APERture command will disable auto NPLC.

Table 4-17
Auto NPLC; ACI

Resolution	NPLC value (Auto NPLC enabled)
6½ digits*	10
5½ digits*	0.02
4½ digits*	0.01
Auto resolution enabled	1

* Auto resolution disabled.

Table 4-18
Auto NPLC; DCI

Measurement type	Resolution	NPLC (Auto NPLC Enabled)
Normal	7½ digits*	2
Normal	6½ digits*	0.2
Normal	5½ digits*	0.02
Normal	4½ digits*	0.01
Normal	Auto resolution enabled	1
In-circuit	5½ digits*	1

* Auto resolution disabled.

Table 4-19
Auto NPLC; ACV

Measurement type	Resolution	NPLC (Auto NPLC enabled)
RMS, average	7½ digits*	10
RMS, average	6½ digits*	10
RMS, average	5½ digits*	0.02
RMS, average	4½ digits*	0.01
RMS, average	3½ digits*	0.01
RMS, average	Auto resolution enabled	1
Low freq RMS	Any*	Selection not used**
Low freq RMS	Auto resolution enabled	Selection not used**
Positive and negative peak	Any*	Selection not used**
Positive and negative peak	Auto resolution enabled	Selection not used**

* Auto resolution disabled.
** The currently selected NPLC value is not used for this measurement type.

Table 4-20
Auto NPLC; DCV, Ω2 and Ω4

Resolution	NPLC value (Auto NPLC enabled)
7½ digits*	2
6½ digits*	0.2
5½ digits*	0.02
4½ digits*	0.01
3½ digits*	0.01
Auto resolution enabled	1

* Auto resolution disabled.

Programming example

```
10  OUTPUT 716; ":curr:ac:nplc:auto  on; auto?"
20  ENTER 716; A$
30  PRINT A
40  END
```

Line 10 Enables auto NPLC and then queries the state of auto NPLC.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of auto NPLC (1).

4.19.7 :COUPling AC | DC

[:SENSe[1]]:CURRent:AC:COUPling AC|DC — Specify coupling for ACI
[:SENSe[1]]:VOLTage:AC:COUPling AC|DC — Specify coupling for ACV
[:SENSe[1]]:FREQuency:COUPling AC|DC — Specify coupling for FREQ

Parameters

AC AC coupling
DC AC+DC coupling

Formats

:curr:ac:coup ac :volt:ac:coup ac :freq:coup ac
:curr:ac:coup dc :volt:ac:coup dc :freq:coup dc

Defaults

Power-up	Saved power-on setup
*RST	AC
:SYSTem:PRESet	AC

Query

:COUPling?	Query currently programmed coupling
Short-form format:	:curr:ac:coup?
	:volt:ac:coup?
	:freq:coup?
Response message:	AC or DC

Description

This command is used to select the input coupling for the AC, ACV and the FREQ functions. When AC coupling is selected, a DC blocking capacitor is placed in series with the AC measurement circuit. This removes the DC component from the measurement.

When DC coupling is selected, the blocking capacitor is removed. Subsequent measurements will reflect both the AC and DC components of the signal (AC+DC).

Programming example

```
10  OUTPUT 716; ":curr:ac:coup  dc; coup?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Configures ACI for AC+DC coupling, and then queries the selected input coupling.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the selected input coupling (DC).

4.19.8 RANGe commands

[:UPPer] <n>

[:SENSe[1]]:CURRent:AC:RANGe[:UPPer] <n>	Set measurement range for ACI
[:SENSe[1]]:CURRent[:DC]:RANGe[:UPPer] <n>	Set measurement range for DCI
[:SENSe[1]]:VOLTage:AC:RANGe[:UPPer] <n>	Set measurement range for ACV
[:SENSe[1]]:VOLTage[:DC]:RANGe[:UPPer] <n>	Set measurement range for DCV
[:SENSe[1]]:RESistance:RANGe[:UPPer] <n>	Set measurement range for Ω2
[:SENSe[1]]:FRESistance:RANGe[:UPPer] <n>	Set measurement range for Ω4

Parameters

<n>	= 0 to 2.1	Expected reading in amps (ACI and DCI)
	= 0 to 775	Expected reading in AC volts (ACV)
	= 0 to 1100	Expected reading in DC volts (DCV)
	= 0 to 1.05e9	Expected reading in ohms (Ω2)
	= 0 to 2.1e5	Expected reading in ohms (Ω4)
	= DEFault	2.1 (ACI and DCI)
		775 (ACV)
		1100 (DCV)
		1.05e9 (Ω2)
		2.1e5 (Ω4)
	= MINimum	0 (All functions)
	= MAXimum	Same as DEFault

Formats

```
:curr:ac:rang  <n>
:curr[:dc]:rang  <n>
:volt:ac:rang  <n>
:volt[:dc]:rang  <n>
:res:rang  <n>
:fres:rang  <n>
```

Defaults

Power-up	Saved power-on setup
*RST	2.1 (ACI and DCI)
	775 (ACV)
	1100 (DCV)
	1.05e9 (Ω2)
	2.1e5 (Ω4)
:SYSTem:PRESet	Same as *RST

Query

:RANGe[:UPPer]?		Query ACI measurement range
:RANGe[:UPPer]?	DEFault	Query *RST default range
:RANGe[:UPPer]?	MINimum	Query lowest measurement range
:RANGe[:UPPer]?	MAXimum	Query highest measurement range

Short-form formats:

:curr:ac:rang?	:curr[:dc]:rang?
:curr:ac:rang? xxx	:curr[:dc]:rang? xxx
:volt:ac:rang?	:volt[:dc]:rang?
:volt:ac:rang? xxx	:volt[:dc]:rang? xxx
:res:rang?	:fres:rang?
:res:rang? xxx	:fres:rang? xxx

where; xxx = def, min or max

Response message: 0 to 1050000000

Description

This command is used to manually select the measurement range for the specifed measurement function. The range is selected by specifying the expected reading as an aboslute value. The Model 2001 will then go to the most sensitive range that will accommodate that expected reading. For example, if you expect a reading of approximately 100mA, simply let the parameter (<n>) = 0.1 (or 100e-3) in order to select the 200mA range.

Programming example

```
10  OUTPUT 716; ":curr:ac:rang  125e-6; rang?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Specifies the expected reading to be 125µA AC, and then queries the selected measurement range.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the currently selected measurement range (0.0002).

:AUTO <b>|ONCE

[:SENSe[1]]:CURRent:AC:RANGe:AUTO <b>|ONCE	Control auto range for ACI
[:SENSe[1]]:CURRent[:DC]:RANGe:AUTO <b>|ONCE	Control auto range for DCI
[:SENSe[1]]:VOLTage:AC:RANGe:AUTO <b>|ONCE	Control auto range for ACV
[:SENSe[1]]:VOLTage[:DC]:RANGe:AUTO <b>|ONCE	Control auto range for DCV
[:SENSe[1]]:RESistance:RANGe:AUTO <b>|ONCE	Control auto range for Ω2
[:SENSe[1]]:FRESistance:RANGe:AUTO <b>|ONCE	Control auto range for Ω4

Parameters

<b>	= 1 or ON	Enable auto range
	= 0 or OFF	Disable auto range
	ONCE	Enable and then disable auto range

Formats

:curr:ac:rang:auto <b>	:curr[:dc]:rang:auto <b>
:curr:ac:rang:auto ONCE	:curr[:dc]:rang:auto ONCE
:volt:ac:rang:auto <b>	:volt[:dc]:rang:auto <b>
:volt:ac:rang:auto ONCE	:volt[:dc]:rang:auto ONCE
:res:rang:auto <b>	:fres:rang:auto <b>
:res:rang:auto ONCE	:fres:rang:auto ONCE

Defaults

Power-up	Saved power-on setup
*RST	ON (all functions)
:SYSTem:PRESet	ON (all functions)

Query

:AUTO?	Query autorange (on or off)
Short-form formats:	:curr:ac:rang:auto?
	:curr[:dc]:rang:auto?
	:volt:ac:rang:auto?
	:volt[:dc]:rang:auto?
	:res:rang:auto?
	:fres:rang:auto?
Response message:	1 (on) or 0 (off)

Description

These commands are used to control autoranging. With autoranging enabled, the instrument will automatically go to the most sensitive range to perform the measurement. Typically, autorange is used for most measurements except when maximum speed is required. With autorange disabled, the instrument does not perform the time consuming search for the correct range. The result is a faster reading rate.

The ONCE parameter is analogous to a momentary toggle switch. When :RANGe:AUTO ONCE is sent, autorange will enable and the most sensitive range will be selected for the input signal. Autorange will then disable, but the selected measurement range will be retained. Note that the instrument must currently be on the specified function in order for ONCE to be effective. Using ONCE while on any other function will result in an error.

The autorange command (:RANGe:AUTO) is coupled to the command that manually selects the measurement range (:RANGe <n>). When autorange is enabled, the parameter value for :RANGe <n> changes to the automatically selected range value. Thus, when autorange is disabled, the instrument will remain at the automatically selected range. When a valid :RANGe <n> command is sent, autoranging will disable.

When using autorange, upper and lower range limits can be established to keep the instrument from autoranging to ranges that are not going to be used. (see :AUTO: ULIMit and :AUTO:LLIMit commands).

Programming example

```
10  OUTPUT 716; ":curr:ac:rang:auto  on; auto?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables auto range and then queries auto range.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays autorange status (1; on).

:ULIMit <n>

[:SENSe[1]]:CURRent:AC:RANGe:AUTO:ULIMit <n>	Set upper limit for ACI
[:SENSe[1]]:CURRent[:DC]:RANGe:AUTO:ULIMit <n>	Set upper limit for DCI
[:SENSe[1]]:VOLTage:AC:RANGe:AUTO:ULIMit <n>	Set upper limit for ACV
[:SENSe[1]]:VOLTage[:DC]:RANGe:AUTO:ULIMit <n>	Set upper limit for DCV
[:SENSe[1]]:RESistance:RANGe:AUTO:ULIMit <n>	Set upper limit for Ω2
[:SENSe[1]]:FRESistance:RANGe:AUTO:ULIMit <n>	Set upper limit for Ω4

:LLIMit <n>

[:SENSe[1]]:CURRent:AC:RANGe:AUTO:LLIMit <n>	Set lower limit for ACI
[:SENSe[1]]:CURRent[:DC]:RANGe:AUTO:LLIMit <n>	Set lower limit for DCI
[:SENSe[1]]:VOLTage:AC:RANGe:AUTO:LLIMit <n>	Set lower limit for ACV
[:SENSe[1]]:VOLTage[:DC]:RANGe:AUTO:LLIMit <n>	Set lower limit for DCV
[:SENSe[1]]:RESistance:RANGe:AUTO:LLIMit <n>	Set lower limit for Ω2
[:SENSe[1]:FRESistance:RANGe:AUTO:LLIMit <n>	Set lower limit for Ω4

Parameters

<n>	= 0 to 2.1	Range limit for ACI and DCI
	= 0 to 775	Range limit for ACV
	= 0 to 1100	Range limit for DCV
	= 0 to 1.05e9	Range limit for Ω2
	= 0 to 2.1e5	Range limit for Ω4
	= DEFault	2.1 (ACI and DCI)
		775 (ACV)
		1100 (DCV)
		1.05e9 (Ω2)
		2.1e5 (Ω4)
	= MINimum	0 (All functions)
	= MAXimum	Same as DEFault

Formats

:curr:ac:rang:auto:ulim <n>	:curr:ac:rang:auto:llim <n>
:curr[:dc]:rang:auto:ulim <n>	:curr[:dc]:rang:auto:llim <n>
:volt:ac:rang:auto:ulim <n>	:volt:ac:rang:auto:llim <n>
:volt[:dc]:rang:auto:ulim <n>	:volt[:dc]:rang:auto:llim <n>
:res:rang:auto:ulim <n>	:res:rang:auto:llim <n>
:fres:rang:auto:ulim <n>	:fres:rang:auto:llim <n>

Defaults

Power-up	Saved power-on setup	
*RST	Upper limit	Lower limit
ACI and DCI	2.1	0.0002
ACV	775	0.2
DCV	1100	0.2
Ω2	1.05e9	20
Ω4	2.1e5	20
:SYSTem:PRESet	Same as *RST	

Query

:ULIMit?	Query upper range limit
:ULIMit? DEFault	Query *RST default upper limit
:ULIMit? MINimum	Query lowest allowable upper limit
:ULIMit? MAXimum	Query largest allowable upper limit

:LLIMit?	Query lower range limit
:LLIMit? DEFault	Query *RST default lower limit
:LLIMit? MINimum	Query lowest allowable lower limit
:LLIMit? MAXimum	Query largest allowable lower limit

Short-form formats:

:curr:ac:rang:auto:ulim?
:curr:ac:rang:auto:ulim? xxx
:curr[:dc]:rang:auto:ulim?
:curr[:dc]:rang:auto:ulim? xxx
:volt:ac:rang:auto:ulim?
:volt:ac:rang:auto:ulim? xxx
:volt[:dc]:rang:auto:ulim?
:volt[:dc]:rang:auto:ulim? xxx
:res:rang:auto:ulim?
:res:rang:auto:ulim? xxx
:fres:rang:auto:ulim?
:fres[:dc]:rang:auto:ulim? xxx
:curr:ac:rang:auto:llim?
:curr:ac:rang:auto:llim? xxx
:curr[:dc]:rang:auto:llim?
:curr[:dc]:rang:auto:llim? xxx
:volt:ac:rang:auto:llim?
:volt:ac:rang:auto:llim? xxx
:volt[:dc]:rang:auto:llim?
:volt[:dc]:rang:auto:llim? xxx
:res:rang:auto:llim?
:res:rang:auto:llim? xxx
:fres:rang:auto:llim?
:fres[:dc]:rang:auto:llim? xxx

where; xxx = def, min or max

Response message: 0 to 1050000000

Description

Automatic range changes take time and slow down the reading rate. By setting upper and lower measurement range limits, you can prevent inadvertent range changes to ranges that you do not want to use. As a result, you can speed up the reading rate while using autorange.

The upper range limit is selected by specifying the maximum expected reading that you expect to measure. For example, if the maximum expected reading is approximately 100mA, let the parameter (<n>) = 0.1 (or 100e-3). The lowest (most sensitive) range that can measure 100mA is the 200mA range. Thus, the 200mA range will be selected as the upper range limit. With this upper limit, the instrument cannot uprange to the 2A measurement range.

The lower range limit is selected by specifying the lowest expected reading that you expect to measure. For example, if the lowest expected reading is approximately 10mA, let the parameter (<n>) = 0.01 (or 10e-3). The lowest range that can measure 10mA is the 20mA range. Thus, the 20mA range will be selected as the lower range limit. With this lower limit, the instrument cannot downrange to the 2mA and 200μA measurement ranges.

Programming example

```
10  OUTPUT 716; ":curr:ac:rang:auto:ulim  100e-3"
20  OUTPUT 716; ":curr:ac:rang:auto:llim  1e-3; ulim?; llim?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Selects the 200mA AC range as the upper range limit.
Line 20 Selects the 2mA AC range as the lower range limit, and then queries the range limits.
Line 30 Addresses the Model 2001 to talk.
Line 40 Displays the upper and lower range limits (.2, .002).

4.19.9 :REFerence <n>

[:SENSe[1]]:CURRent:AC:REFerence <n>	Specify reference for ACI
[:SENSe[1]]:CURRent[:DC]:REFerence <n>	Specify reference for DCI
[:SENSe[1]]:VOLTage:AC:REFerence <n>	Specify reference for ACV
[:SENSe[1]]:VOLTage[:DC]:REFerence <n>	Specify reference for DCV
[:SENSe[1]]:RESistance:REFerence <n>	Specify reference for Ω2
[:SENSe[1]]:FRESistance:REFerence <n>	Specify reference for Ω4
[:SENSe[1]]:FREQuency:REFerence <n>	Specify reference for FREQ
[:SENSe[1]]:TEMPerature:REFerence <n>	Specify reference for TEMP

Parameters

<n>	= -2.1 to +2.1	Reference for ACI and DCI
	= -775 to +775	Reference for ACV
	= -1100 to +1100	Reference for DCV
	= 0 to 1.05e9	Reference for Ω2
	= 0 to 2.1e5	Reference for Ω4
	= 0 to 1.5e7	Reference for FREQ
	= -328 to +3310	Reference for TEMP (°F)
	= -200 to +1821	Reference for TEMP (°C)
	= 73 to 2094	Reference for TEMP (K)
	= DEFault	0 (All functions)
	= MINimum	Minimum value for specified function
	= MAXimum	Maximum value for specified function

Formats

```
:curr:ac:ref  <n>
:curr[:dc]:ref  <n>
:volt:ac:ref  <n>
:volt[:dc]:ref  <n>
:res:ref  <n>
:fres:ref  <n>
:freq:ref  <n>
:temp:ref  <n>
```

Defaults

Power-up	Saved power-on setup
*RST	0 (all functions)
:SYSTem:PRESet	0 (all functions)

Query

:REFerence?		Query programmed reference value
:REFerence?	DEFault	Query *RST default reference value
:REFerence?	MINimum	Query lowest allowable reference value
:REFerence?	MAXimum	Query largest allowable reference value
Short-form formats:	:curr:ac:ref?	:curr[:dc]:ref?
	:curr:ac:ref? xxx	:curr[:dc]:ref? xxx
	:volt:ac:ref?	:volt[:dc]:ref?
	:volt:ac:ref? xxx	:volt[:dc]:ref? xxx
	:res:ref?	:fres:ref?
	:fres:ref? xxx	:fres:ref? xxx
	:freq:ref?	:temp:ref?
	:freq:ref? xxx	:temp:ref? xxx
	where; xxx = def, min or max	
Response message:	-1100 to +3310	

Description

These commands are used to establish a reference value for the specified function. When Reference is enabled (see :REFerence:STATe), the result (X) will be the algebraic difference between the input signal and the reference value:

X = Input signal - Reference

Note that the result (X) is the value that is used for the math calculation (see :CALCulate1 subsystem). If the Reference is zero or disabled, then the normal reading is used for the math calculation.

The reference value is not scaled according to what range the instrument is on. For example, a reference value of 0.1 on DCI is 100mA on all the DC current ranges. A reference value cannot cause the display to overrange. For example, the result of a 2A reference can be displayed on any range as long as the input signal does not exceed the selected range. For example, assume a 100mA signal is referenced to 2A. The -1.9A result (100mA - 2A = -1.9A) will be displayed on the 200mA range as follows:

-1.9000e+03mAAC

Note that the 4½ digit reading is in exponent form and reads as:

-1.9000×10^3 mA AC which equals -1.9A AC.

From the front panel, a reference is set using the REL feature.

The :REFerence <n> command is coupled to the :ACQuire command. The last command sent (:REFerence <n> or :ACQuire) will establish the reference. When a reference is set using the :REFerence <n> command, the :REFerence? query command will return the value sent with the :REFerence <n> command. Conversely, when a reference is set using the :ACQuire command, the :REFerence? query command will return the acquired reference value.

A negative reference value will automatically be changed to zero when units are changed from volts to dB or dBm.

:STATe <b>

[:SENSe[1]]:CURRent:AC:REFerence:STATe <b>	Control reference for ACI
[:SENSe[1]]:CURRent[:DC]:REFerence:STATe <b>	Control reference for DCI
[:SENSe[1]]:VOLTage:AC:REFerence:STATe <b>	Control reference for ACV
[:SENSe[1]]:VOLTage[:DC]:REFerence:STATe <b>	Control reference for DCV
[:SENSe[1]]:RESistance:REFerence:STATe <b>	Control reference for Ω2
[:SENSe[1]]:FRESistance:REFerence:STATe <b>	Control reference for Ω4
[:SENSe[1]]:FREQuency:REFerence:STATe <b>	Control reference for FREQ
[:SENSe[1]]:TEMPerature:REFerence:STATe <b>	Control reference for TEMP

Parameters

<b>	= 1 or ON	Enable reference
	= 0 or OFF	Disable reference

Formats

:curr:ac:ref:stat <b>	:curr[:dc]:ref:stat <b>
:volt:ac:ref:stat <b>	:volt[:dc]:ref:stat <b>
:res:ref:stat <b>	:fres:ref:stat <b>
:freq:ref:stat <b>	:temp:ref:stat <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF (all functions)
:SYSTem:PRESet	OFF (all functions)

Query

:STATe?	Query state of reference	
Short-form formats:	:curr:ac:ref:stat?	:curr[:dc]:ref:stat?
	:volt:ac:ref:stat?	:volt[:dc]:ref:stat?
	:res:ref:stat?	:fres:ref:stat?
	:freq:ref:stat?	:temp:ref:stat?
Response message:	1 (on) or 0 (off)	

Description

These commands are used to enable or disable Reference for the specified function. When enabled, the displayed reading will include the programmed reference value (see :REFerence <n> and :ACQuire). When disabled, the displayed reading will not include the reference value.

Programming example

```
10  OUTPUT 716; ":curr:ac:ref  1; ref:stat  on; ref:stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Three commands in this program message; the first sets a reference value of 1A, the second enables Reference, and the third queries Reference (on or off).

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the status of Reference (1; on).

:ACQuire

[:SENSe[1]]:CURRent:AC:REFerence:ACQuire	Acquire Reference for ACI
[:SENSe[1]]:CURRent[:DC]:REFerence:ACQuire	Acquire Reference for DCI
[:SENSe[1]]:VOLTage:AC:REFerence:ACQuire	Acquire Reference for ACV
[:SENSe[1]]:VOLTage[:DC]:REFerence:ACQuire	Acquire Reference for DCV
[:SENSe[1]]:RESistance:REFerence:ACQuire	Acquire Reference for Ω2
[:SENSe[1]]:FRESistance:REFerence:ACQuire	Acquire Reference for Ω4
[:SENSe[1]]:FREQuency:REFerence:ACQuire	Acquire Reference for FREQ
[:SENSe[1]]:TEMPerature:REFerence:ACQuire	Acquire Reference for TEMP

Formats

:curr:ac:ref:acq	:curr[:dc]:ref:acq
:volt:ac:ref:acq	:volt[:dc]:ref:acq
:res:ref:acq	:fres:ref:acq
:freq:ref:acq	:temp:ref:acq

Description

When one of these commands is sent, the measured input signal will be acquired and established as the reference value. This command is typically used to zero the display. For example, if the instrument is displaying a 2mA offset, sending this command and enabling Reference (see :STATe) will zero the display.

This command is functional only if the instrument is on the specified measurement function. Sending this command while in any other function will cause an error. Also, if the latest reading is overflowed ("OFLO") or a reading has not been triggered ("----"), an error will occur when this command is sent.

The :ACQuire command is coupled to the :REFerence <n> command. The last command sent (:ACQuire or :REFerence <n>) will establish the reference. When a reference is set using the :ACQuire command, the :REFerence? query command will return the acquired reference value. Conversely, when a reference is set using the :REFerence <n> command, the :REFerence? query command will return the value sent with the :REFerence <n> command.

Programming example

```
10  OUTPUT 716; ":func  'curr:ac' :curr:ac:ref:acq; stat  on"
20  OUTPUT 716; ":curr:ac:ref?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Three commands on this line; the first selects the ACI function, the second acquires the displayed reading as the reference, and the third enables Reference.

Line 20 Queries the programmed reference value.

Line 30 Addresses the Model 2001 to talk.

Line 40 Displays the programmed reference value.

4.19.10 :DIGits <n>

[:SENSe[1]]:CURRent:AC:DIGits <n>	Specify resolution for ACI
[:SENSe[1]]:CURRent[:DC]:DIGits <n>	Specify resolution for DCI
[:SENSe[1]]:VOLTage:AC:DIGits <n>	Specify resolution for ACV
[:SENSe[1]]:VOLTage[:DC]:DIGits <n>	Specify resolution for DCV
[:SENSe[1]]:RESistance:DIGits <n>	Specify resolution for Ω2
[:SENSe[1]]:FRESistance:DIGits <n>	Specify resolution for Ω4
[:SENSe[1]]:FREQuency:DIGits <n>	Specify resolution for FREQ
[:SENSe[1]]:TEMPerature:DIGits <n>	Specify resolution for TEMP

Parameters

<n>	= 4	3½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4 3½ digits (1° resolution) for TEMP 4 digits for FREQ
	= 5	4½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4 4½ digits (0.1° resolution) for TEMP 5 digits for FREQ
	= 6	5½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4 5½ digits (0.01° resolution) for TEMP
	= 7	6½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4 6½ digits (0.001° resolution) for TEMP
	= 8	7½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4
	= DEFault	6½ digits for DCI, DCV, Ω2 and Ω4 5½ digits for ACI and ACV 5½ digits (0.01° resolution) for TEMP 5 digits for FREQ
	= MINimum	3½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4 3½ digits (1° resolution) for TEMP 4 digits for FREQ
	= MAXimum	7½ digits for DCI, ACI, ACV, DCV, Ω2, Ω4 6½ digits (0.001° resolution) for TEMP 5 digits for FREQ

Formats

:curr:ac:dig <n>	:volt:ac:dig <n>
:curr[:dc]:dig <n>	:volt[:dc]:dig <n>
:res:dig <n>	:freq:dig <n>
:fres:dig <n>	:temp:dig <n>

Defaults

Power-up	Saved power-on setup
*RST	6½ digits for DCI, DCV, Ω2 and Ω4 5½ digits for ACI and ACV 5½ digits (0.01° resolution) for TEMP 5 digits for FREQ
:SYSTem:PRESet	Same as *RST

Query

:DIGits?		Query selected resolution
:DIGits?	DEFault	Query *RST default resolution
:DIGits?	MINimum	Query minimum allowable resolution
:DIGits?	MAXimum	Query maximum allowable resolution

Short-form formats:

:curr:ac:dig?	:curr[:dc]:dig?
:curr:ac:dig? xxx	:curr[:dc]:dig? xxx
:volt:ac:dig?	:volt[:dc]:dig?
:volt:ac:dig? xxx	:volt[:dc]:dig? xxx
:res:dig?	:fres:dig?
:res:dig? xxx	:fres:dig? xxx
:freq:dig?	:temp:dig?
:freq:dig? xxx	:temp:dig? xxx

where; xxx = def, min or max

Description

These commands are used to select display resolution for the specified measurement function.

Even though the parameters for this command are expressed as integers (4 to 8), you can specify resolution using real numbers. For example, to select 3½ digit resolution let <n> = 3.5, for 4½d let <n> = 4.5, and so on. Internally, the instrument rounds the entered parameter value to the nearest integer. For example:

3.4 is rounded down to 3 (Illegal parameter)
3.5 is rounded up to 4
4.4 is rounded down to 4
4.5 is rounded up to 5
4.6 is rounded up to 5

Programming example

```
10  OUTPUT 716; ":curr:ac:dig  4.5; res?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets ACI resolution to 4½d, and then queries the selected resolution.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the selected resolution (5).

:AUTO <b>|ONCE

[:SENSe[1]]:CURRent:AC:DIGits:AUTO <b>|ONCE	Control auto resolution for ACI
[:SENSe[1]]:CURRent[:DC]:DIGits:AUTO <b>|ONCE	Control auto resolution for DCI
[:SENSe[1]]:VOLTage:AC:DIGits:AUTO <b>|ONCE	Control auto resolution for ACV
[:SENSe[1]]:VOLTage[:DC]:DIGits:AUTO <b>|ONCE	Control auto resolution for DCV
[:SENSe[1]]:RESistance:DIGits:AUTO <b>|ONCE	Control auto resolution for Ω2
[:SENSe[1]]:FRESistance:DIGits:AUTO <b>|ONCE	Control auto resolution for Ω4
[:SENSe[1]]:TEMPerature:DIGits:AUTO <b>|ONCE	Control auto resolution for TEMP

Parameters

<b>	= 1 or ON	Enable auto resolution
	= 0 or OFF	Disable auto resolution
ONCE		Enable and then disable auto resolution

Formats

:curr:ac:dig:auto <b>
:curr:ac:dig:auto once
:volt:ac:dig:auto <b>
:volt:ac:dig:auto once
:res:dig:auto <b>
:res:dig:auto once
:temp:dig:auto <b>
:temp:dig:auto once
:curr[:dc]:dig:auto <b>
:curr[:dc]:dig:auto once
:volt[:dc]:dig:auto <b>
:volt[:dc]:dig:auto once
:fres:dig:auto <b>
:fres:dig:auto once

Defaults

Power-up	Saved power-on setup
*RST	ON (all functions)
:SYSTem:PRESet	ON (all functions)

Query

:AUTO? Query state of auto resolution

Short-form formats: :curr:ac:dig:auto? :curr[:dc]:dig:auto?
:volt:ac:dig:auto? :volt[:dc]:dig:auto?
:res:dig:auto? :fres:dig:auto?
:temp:dig:auto?

Response message: 0 (off) or 1 (on)

Description

These commands are used to enable or disable auto resolution for the specified function. With auto resolution selected, the instrument will automatically select the optimum display resolution. The resolution selected by the instrument is summarized by Tables 4-21 through 4-25.

The ONCE parameter is analogous to a momentary toggle switch. When :AUTO ONCE is sent, auto resolution will turn on momentarily and then disable. While enabled, resolution will be selected automatically. Auto resolution will then disable but the selected value will be retained.

The auto resolution command (:DIGits:AUTO) is coupled to the command that manually selects resolution (:DIGits <n>). When auto resolution is enabled, the parameter value for :DIGits <n> changes to the automatically selected resolution value. Thus, when auto resolution is disabled, the instrument will remain at the automatically selected resolution.

Table 4-21
Auto resolution; ACI

NPLC* selection	Resolution (Auto resolution enabled)
10**	6½ digits
0.02 to <10**	5½ digits
0.01 to <0.02**	4½ digits
Auto NPLC or auto aperture enabled	5½ digits

* To convert NPLC to aperture, see :APERture.
** Auto NPLC and auto aperture disabled.

Table 4-22
Auto resolution; DCI

Measurement type	NPLC* selection	Resolution (Auto resolution enabled)
Normal	2 to 10**	7½ digits
Normal	0.2 to <2**	6½ digits
Normal	0.02 to <0.2**	5½ digits
Normal	0.01 to <0.02**	4½ digits
Normal	Auto NPLC or auto aperture enabled	6½ digits
In-circuit	Any	5½ digits

* To convert NPLC values to aperture values, see :APERture.
** Auto NPLC and auto aperture disabled.

Table 4-23
Auto resolution; ACV

Measurement type	NPLC* selection	Resolution (Auto resolution enabled)
RMS, average	10**	6½ digits
RMS, average	0.02 to <10**	5½ digits
RMS, average	0.01 to <0.02**	4½ digits
RMS, average	Auto NPLC or auto aperture enabled	5½ digits
Low frequency RMS	Any	5½ digits
Peak, positive and negative peak spikes	Any	3½ digits

* To convert NPLC values to aperture values, see :APERture.
** Auto NPLC and auto aperture disabled.

Table 4-24
Auto resolution; DCV, Ω2 and Ω4

NPLC* selection	Resolution (Auto resolution enabled)
2 to 10**	7½ digits
0.2 to <2**	6½ digits
0.02 to <0.2**	5½ digits
0.01 to <0.02**	4½ digits
Auto NPLC or auto aperture enabled	6½ digits

* To convert NPLC values to aperture values, see :APERture.
** Auto NPLC and auto aperture disabled.

Table 4-25
Auto resolution; TEMP

Sensor	Resolution*	
	Digits	Degrees
RTD	5½ d	0.01°
Thermocouples J, K, T, E	4½ d	0.1°
Thermocouples R, S, B	3½ d	1°

* Auto resolution enabled.

Programming example

```
10 OUTPUT 716; ":curr:ac:dig:auto  on; auto?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Enables auto resolution for ACI, and then queries the state of auto resolution.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of auto resolution (1).

4.19.11 :AVERage commands

:TCONtrol <name>

[:SENSe[1]]:CURRent:AC:AVERage:TCONtrol <name>	Select filter type for ACI
[:SENSe[1]]:CURRent[:DC]:AVERage:TCONtrol <name>	Select filter type for DCI
[:SENSe[1]]:VOLTage:AC:AVERage:TCONtrol <name>	Select filter type for ACV
[:SENSe[1]]:VOLTage[:DC]:AVERage:TCONtrol <name>	Select filter type for DCV
[:SENSe[1]]:RESistance:AVERage:TCONtrol <name>	Select filter type for Ω2
[:SENSe[1]]:FRESistance:AVERage:TCONtrol <name>	Select filter type for Ω4
[:SENSe[1]]:TEMPerature:AVERage:TCONtrol <name>	Select filter type for TEMP

Parameters

<name>	= REPeat	Select repeating filter
	= MOVing	Select moving filter

Formats

```
:curr:ac:aver:tcon <name>     :curr[:dc]:aver:tcon <name>
:volt:ac:aver:tcon <name>     :volt[:dc]:aver:tcon <name>
:res:aver:tcon <name>         :fres:aver:tcon <name>
:temp:aver:tcon <name>
```

Defaults

Power-up	Saved power-on setup
*RST	REPeat (all functions)
:SYSTem:PRESet	MOVing (all functions)

Query

:TCONtrol?	Query filter type	
Short-form formats:	:curr:ac:aver:tcon?	:curr[:dc]:aver:tcon?
	:volt:ac:aver:tcon?	:volt[:dc]:aver:tcon?
	:res:aver:tcon?	:fres:aver:tcon?
	:temp:aver:tcon?	
Response message:	REP or MOV	

Description

These commands are used to select the type of averaging filter (REPeat or MOVing) for the specified function. With the repeating filter selected and enabled, the instrument will simply acquire and average a specified number of readings and display the result. This process continues for each new group of readings.

With the moving filter selected and enabled, the instrument will acquire and average a specified number of readings. Each subsequent new reading will then be added to the group while the oldest reading will be discarded. With each new reading, the average is re-calculated and displayed.

The number of readings that are averaged by the filter is set with the :AVERage:COUNt command. The :AVERage[:STATe] command is used to enable or disable the filter.

Changing the filter type will disable auto filter.

Programming example

```
10  OUTPUT 716; ":curr:ac:aver:tcon  rep; tcon?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects the repeating filter, and then queries the filter type.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the filter type (REP).

:COUNt <n>

[:SENSe[1]]:CURRent:AC:AVERage:COUNt <n>	Specify filter count for ACI
[:SENSe[1]]:CURRent[:DC]:AVERage:COUNt <n>	Specify filter count for DCI
[:SENSe[1]]:VOLTage:AC:AVERage:COUNt <n>	Specify filter count for ACV
[:SENSe[1]]:VOLTage[:DC]:AVERage:COUNt <n>	Specify filter count for DCV
[:SENSe[1]]:RESistance:AVERage:COUNt <n>	Specify filter count for Ω2
[:SENSe[1]]:FRESistance:AVERage:COUNt <n>	Specify filter count for Ω4
[:SENSe[1]]:TEMPerature:AVERage:COUNt <n>	Specify filter count for TEMP

Parameters

<n>	= 1 to 100	Specify filter count
	= DEFault	10
	= MINimum	1
	= MAXimum	100

Formats

:curr:ac:aver:coun <n>	:curr[:dc]:aver:coun <n>
:volt:ac:aver:coun <n>	:volt[:dc]:aver:coun <n>
:res:aver:coun <n>	:fres:aver:coun <n>
:temp:aver:coun <n>	

Defaults

Power-up	Saved power-on setup
*RST	10 (all functions)
:SYSTem:PRESet	10 (all functions)

Query

:COUNt?	Query filter count
:COUNt? DEFault	Query the *RST default filter count
:COUNt? MINimum	Query the lowest allowable filter count
:COUNt? MAXimum	Query the largest allowable filter count
Short-form formats:	:curr:ac:aver:coun? :curr[:dc]:aver:coun?
	:curr:ac:aver:coun? xxx :curr[:dc]:aver:coun? xxx
	:volt:ac:aver:coun? :volt[:dc]:aver:coun?
	:volt:ac:aver:coun? xxx :volt[:dc]:aver:coun? xxx
	:res:aver:coun? :fres:aver:coun?
	:res:aver:coun? xxx :frest:aver:coun? xxx
	:temp:aver:coun?
	:temp:aver:coun? xxx
Response message:	1 to 100

Description

These commands are used to specify the filter count. In general, the filter count is the number of readings that are acquired and stored in the filter buffer for the averaging calculation. The larger the filter count, the more filtering that is performed.

Programming example

```
10  OUTPUT 716; ":curr:ac:aver:coun  20; coun?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the filter count to 20, and then queries the filter count.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the filter count (20).

:ADVanced commands

:NTOLerance <n>

[:SENSe[1]]:CURRent:AC:AVERage:ADVanced:NTOLerance <n>	Specify noise tolerance (ACI)
[:SENSe[1]]:CURRent[:DC]:AVERage:ADVanced:NTOLerance <n>	Specify noise tolerance (DCI)
[:SENSe[1]]:VOLTage:AC:AVERage:ADVanced:NTOLerance <n>	Specify noise tolerance (ACV)
[:SENSe[1]]:VOLTage[:DC]:AVERage:ADVanced:NTOLerance <n>	Specify noise tolerance (DCV)
[:SENSe[1]]:RESistance:AVERage:ADVanced:NTOLerance <n>	Specify noise tolerance (Ω2)
[:SENSe[1]]:FRESistance:AVERage:ADVanced:NTOLerance <n>	Specify noise tolerance (Ω4)

Parameters

<n>	= 1 to 100	Specify noise tolerance in percent (±)
	= DEFault	±5%
	= MINimum	0%
	= MAXimum	±100%

Formats

:curr:ac:aver:adv:ntol <n>	:curr[:dc]:aver:adv:ntol <n>
:volt:ac:aver:adv:ntol <n>	:volt[:dc]:aver:adv:ntol <n>
:res:aver:adv:ntol <n>	:fres:aver:adv:ntol <n>

Defaults

Power-up	Saved power-on setup
*RST	±1% for DCI, DCV, Ω2 and Ω4
	±5% for ACI and ACV
:SYSTem:PRESet	Same as *RST

Query

:NTOLerance?	Query noise tolerance
:NTOLerance? DEFault	Query *RST default noise tolerance
:NTOLerance? MINimum	Query lowest allowable noise tolerance
:NTOLerance? MAXimum	Query largest allowable noise tolerance

Short-form formats:
:curr:ac:aver:adv:ntol?
:curr:ac:aver:adv:ntol? xxx
:curr[:dc]:aver:adv:ntol?
:curr[:dc]:aver:adv:ntol? xxx
:volt:ac:aver:adv:ntol?
:volt:ac:aver:adv:ntol? xxx
:volt[:dc]:aver:adv:ntol?
:volt[:dc]:aver:adv:ntol? xxx
:res:aver:adv:ntol?
:res:aver:adv:ntol? xxx
:fres:aver:adv:ntol?
:fres:aver:adv:ntol? xxx

Response message: 0 to 100 (±%)

Description

Each measurement function (except TEMP and FREQ) can utilize the advanced filter which adds a noise tolerance window to the averaging algorithm. These commands are used to set the noise tolerance level of the advanced filter for the specifed function. The :ADVanced[:STATe] commands are used to enable or disable the advanced filter.

The noise tolerance level is expressed as a percent of the last averaged reading. In general, if the noise is within this window, the reading is simply based on the normal averaging algorithm. If a reading is outside this window, then the advanced averaging algorithm is used. See Section 3 for details.

Programming example

```
10  OUTPUT 716; ":curr:ac:aver:adv:ntol  20; ntol?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the noise tolerance to ±20%, and then queries the noise tolerance level.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the noise tolerance band (20).

[:STATe] <b>

[:SENSe[1]]:CURRent:AC:AVERage:ADVanced[:STATe] <b>	Control advanced filter for ACI
[:SENSe[1]]:CURRent[:DC]:AVERage:ADVanced[:STATe] <b>	Control advanced filter for DCI
[:SENSe[1]]:VOLTage:AC:AVERage:ADVanced[:STATe] <b>	Control advanced filter for ACV
[:SENSe[1]]:VOLTage[:DC]:AVERage:ADVanced[:STATe] <b>	Control advanced filter for DCV
[:SENSe[1]]:RESistance:AVERage:ADVanced[:STATe] <b>	Control advanced filter for Ω2
[:SENSe[1]]:FRESistance:AVERage:ADVanced[:STATe] <b>	Control advanced filter for Ω4

Parameters

<b>	= 0 or OFF	Disable advanced filter
	= 1 or ON	Enable advanced filter

Formats

:curr:ac:aver:adv <b>	:curr[:dc]:aver:adv <b>
:volt:ac:aver:adv <b>	:volt[:dc]:aver:adv <b>
:res:aver:adv <b>	:fres:aver:adv <b>

Defaults

Power-up	Saved power-on setup
*RST	ON (all functions)
:SYSTem:PRESet	ON (all functions)

Query

:STATe]?	Query state of advanced filter
Short-form formats:	:curr:ac:aver:adv?
	:curr[:dc]:aver:adv?
	:volt:ac:aver:adv?
	:volt[:dc]:aver:adv?
	:res:aver:adv?
	:fres:aver:adv?
Response message:	0 (off) or 1 (on)

Description

These commands are used to enable or disable the advanced filter for the specified function. The :ADVanced:NTOLerance commands are used to set tolerance levels.

Programming example

```
10  OUTPUT 716; ":curr:ac:aver:adv  on; adv?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables the advanced filter and then queries the state of the advanced filter.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of noise tolerance (1; on).

[:STATe] <b>

[:SENSe[1]]:CURRent:AC:AVERage[:STATe] <b>	Control filter for ACI
[:SENSe[1]]:CURRent[:DC]:AVERage[:STATe] <b>	Control filter for DCI
[:SENSe[1]]:VOLTage:AC:AVERage[:STATe] <b>	Control filter for ACV
[:SENSe[1]]:VOLTage[:DC]:AVERage[:STATe] <b>	Control filter for DCV
[:SENSe[1]]:RESistance:AVERage[:STATe] <b>	Control filter for Ω2
[:SENSe[1]]:FRESistance:AVERage[:STATe] <b>	Control filter for Ω4
[:SENSe[1]]:TEMPerature:AVERage[:STATe] <b>	Control filter for TEMP

Parameters

<b>	= 0 or OFF	Disable the digital filter
	= 1 or ON	Enable the digital filter

Formats

:curr:ac:aver <b>	:curr[:dc]:aver <b>
:volt:ac:aver <b>	:volt[:dc]:aver <b>
:res:aver <b>	:fres:aver <b>
:temp:aver <b>	

Defaults

Power-up	Saved power-on setup
*RST	OFF (all functions)
:SYSTem:PRESet	OFF (ACI, ACV and TEMP) ON (DCI, DCV, Ω2 and Ω4)

Query

:STATe]?	Query state of digital filter	
Short-form format:	:curr:ac:aver?	:curr[:dc]:aver?
	:volt:ac:aver?	:volt[:dc]:aver?
	:res:aver?	:fres:aver?
	:temp:aver?	
Response message:	0 (off) or 1 (on)	

Description

These commands are used to enable or disable the digital averaging filter for the specified function. When enabled, readings will be filtered according to how the filter is configured.

Programming example

```
10  OUTPUT 716; ":curr:ac:aver  on; aver?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables the filter, and then queries the state of the filter.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of the filter (1; on).

:AUTO <b>|ONCE

[:SENSe[1]]:CURRent:AC:AVERage:AUTO <b>|ONCE	Control auto filter for ACI
[:SENSe[1]]:CURRent[:DC]:AVERage:AUTO <b>|ONCE	Control auto filter for DCI
[:SENSe[1]]:VOLTage:AC:AVERage:AUTO <b>|ONCE	Control auto filter for ACV
[:SENSe[1]]:VOLTage[:DC:]AVERage:AUTO <b>|ONCE	Control auto filter for DCV
[:SENSe[1]]:RESistance:AVERage:AUTO <b>|ONCE	Control auto filter for Ω2
[:SENSe[1]]:FRESistance:AVERage:AUTO <b>|ONCE	Control auto filter for Ω4
[:SENSe[1]]:TEMPerature:AVERage:AUTO <b>|ONCE	Control auto filter for TEMP

Parameters

<b>	= 0 or OFF	Disable auto filter
	= 1 or ON	Enable auto filter
ONCE		Enable and then disable auto filter

Formats

:curr:ac:aver:auto <b>	:curr[:dc]:aver:auto <b>
:curr:ac:aver:auto once	:curr[:dc]:aver:auto once
:volt:ac:aver:auto <b>	:volt[:dc]:aver:auto <b>
:volt:ac:aver:auto once	:volt:dc:aver:auto once
:res:aver:auto <b>	:fres:aver:auto <b>
:res:aver:auto once	:fres:aver:auto once
:temp:aver:auto <b>	
:temp:aver:auto ONCE	

Defaults

Power-up	Saved power-on setup
*RST	OFF (all functions)
:SYSTem:PRESet	ON (ACI, DCI, ACV, DCV, Ω2 and Ω4)
	OFF (TEMP)

Query

:AUTO?	Query state of auto filter
Short-form formats:	:curr:ac:aver:auto? :curr[:dc]:aver:auto?
	:volt:ac:aver:auto? :volt[:dc]:aver:auto?
	:res:aver:auto? :fres:aver:auto?
	:temp:aver:auto?
Response message:	0 (off) or 1 (on)

Description These commands are used to control auto filter for the specifed function. The configuration for the filter is summarized in the following table:

Auto filter enabled

	Filter		
Measurement function	**State**	**Type**	**Count**
ACI	Off	Moving	10
DCI (Normal)	On	Moving	10
DCI (In-circuit)	Off	Moving	10
ACV (RMS, Avg, LFRMS)	Off	Moving	10
ACV (Peak, PPeak, NPeak)	On	Moving	10
DCV, Ω2, Ω4, TEMP	On	Moving	10

Note from the table that enabling auto filter with the Model 2001 on the ACI, or RMS, average or LFRMS ACV function will disable (off) the filter. For the other measurement functions, enabling auto filter will enable the moving filter and set the filter count to 10.

Disabling auto filter has no effect on the currently programmed filter state and count.

The ONCE parameter is analogous to a momentary toggle switch. When ONCE is sent, the auto filter will turn on momentarily and then disable.

Programming example

```
10  OUTPUT 716; ":curr:ac:aver:auto  on; auto?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables the auto filter for the ACI function, and then queries the state of auto filter.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of auto filter (1; on).

4.19.12 Analog Filter

:FILTer[:LPASs][:STATe] <b>
[:SENSe[1]]:VOLTage[:DC]:FILTer[:LPASs][:STATe] <b> Control analog filter

Parameters

<b>	= 1 or ON	Enable analog filter
	= 0 or OFF	Disable analog filter

Format

:volt:filt <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:FILTer[:LPASs][:STATe]?
Short-form formats: :filt?
Response message: 0 or 1

Description

This command is used to enable or disable the analog filter for the DCV function. When enabled, an RC network filters out high frequency (>10kHz) noise on the input signal. The analog filter is most effective when measuring voltages greater than 2V p-p on the 2V p-p on the 2V or 20V range. See paragraph 3.9.7 for details on the analog filter.

Programming example

```
10  OUTPUT 716; ":volt:filt on; filt?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables the analog filter for DCV and then queries the state.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of the filter (1).

4.19.13

:DETector commands

:FUNCTION] <name>

[:SENSe[1]]:CURRent:AC:DETector[:FUNCTION] <name> Specify detector for ACI
[:SENSe[1]]:VOLTage:AC:DETector[:FUNCTION] <name> Specify detector for ACV

Parameters

ACI:

<name>	= RMS	AC RMS amps measurements
	= AVERage	AC average amps measurements

ACV:

<name>	= RMS	AC RMS volts measurements
	= AVERage	AC average volts measurements
	= LFRMs	Low frequency AC volts measurements
	= PEAK	AC peak volts measurements
	= NPEak	DC negative peak spike volts measurements
	= PPEak	AC positive peak spike volts measurements

Formats

:curr:ac:det <name>
:volt:ac:det <name>

Defaults

Power-up	Saved power-on setup
*RST	RMS (ACI and ACV)
:SYSTem:PRESet	RMS (ACI and ACV)

Query

:FUNCtion]?	Query selected measurement type
Short-form formats:	:curr:ac:det?
	:volt:ac:det?
Response message:	RMS, AVER, LFRM, PEAK, NPE or PPE

Description

These commands are used to select the measurement type for the ACI and ACV functions.

For ACI, use AVERage to make AC average (0.636 of peak) current measurements, and use the RMS parameter to make RMS current measurements.

For ACV, use AVERage to make AC average (0.636 of peak) current measurements. Use the RMS parameter to make RMS current measurements above 100Hz. To make low frequency RMS measurements below 50Hz, use the LFRMs parameter. For measurements between 50Hz and 100Hz, you can use either LFRMs or RMS. However, keep in mind that LFRMs measurements are slower.

The PEAK selection allows you to make peak measurements. For this type of measurement, the instrument will measure the largest peak (positive or negative) for each measurement conversion.

PSPike and NSPike allows you to measure positive or negative peak spikes. The sampling period for each reading is controlled by :PWINdow. Note that a peak spike measurement is considered a DCV measurement even though it is performed on the ACV function (see DCV PEAK SPIKES MEASUREMENT in the specifications).

Programming example

```
10  OUTPUT 716; ":curr:ac:det  aver; det?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects the average detector for ACI and then queries the detector.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the detector (AVER).

4.19.14 :PWINdow <n>

[:SENSe[1]]:VOLTage:AC:DETector:PWINdow <n> Set peak detection window for ACV

Parameters

<n>	= 0.1 to 9.9	Peak spike detection window (in seconds)
	= DEFault	0.1sec window
	= MINimum	0.1sec window
	= MAXimum	9.9sec window

Format :volt:ac:det:pwin <n>

Defaults

Power-up	Saved power-on setup
*RST	0.1sec
:SYSTem:PRESet	0.1sec

Query

:PWINdow?	Query spike detection window
:PWINdow? DEFault	Query *RST default window
:PWINdow? MINimum	Query lowest allowable window
:PWINdow? MAXimum	Query largest allowable window

Short-form formats: :volt:ac:det:pwin?
:volt:ac:det:pwin? def
:volt:ac:det:pwin? min
:volt:ac:det:pwin? max

Response Message: 0.1 to 9.9 (sec)

Description This command is used to set the detection window for peak spike measurements (:NPEak or :PPEak). The instrument will measure and display the largest peak spike that occurs within each specified detection window. For example, for a ½ second window, the instrument will display the peak spike after every ½ second.

Programming example

```
10  OUTPUT 716; ":volt:ac:det:pwin  1; pwin?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Specifies a one second window, and then queries the spike window.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the spike window (1).

4.19.15 :METHod <name>

[:SENSe[1]]:CURRent[:DC]:METHod <name> Specify measurement technique for DCI.

Parameters

<name> =	NORMal	Normal DCI measurement technique
	ICIRcuit	In-circuit DCI measurement technique

Format

:curr[:dc]:meth <name>

Defaults

Power-up	Saved power-on setup
*RST	NORMal
:SYSTem:PRESet	NORMal

Query

:METHod?	Query measurement technique
Short-form format:	:curr:dc:meth?
Response message:	NORM or ICIR

Description

This command is used to select the DCI measurement technique. NORMal is used to make conventional current measurements which are performed by breaking the circuit and placing the ammeter in series with it.

The ICIRcuit selection allows you make an in-circuit current measurement of a wire or circuit board trace. This measurement technique is performed by making four-wire INPUT connections to the wire or trace (the AMPS input is not used). The instrument will then automatically perform a four-wire ohms offset compensated measurement and calculate the current. See front panel operation for complete details on making in-circuit current measurements.

Programming example

```
10  OUTPUT 716; ":curr:dc:meth  icir; meth?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10	Two commands in this program message; the first selects the in-circuit current measurement method, and the second queries the selected method.
Line 20	Addresses the Model 2001 to talk.
Line 30	Displays the selected measurement method (ICIR).

4.19.16 :SOURce <name>

[:SENSe[1]]:FREQuency:SOURce <name> Specify input source for FREQ.

Parameters

<name>	= CURRent	Select current frequency input source
	= VOLTage	Select voltage frequency input source

Format

:freq:sour <name>

Defaults

Power-up	Saved power-on setup
*RST	VOLTage
:SYSTem:PRESet	VOLTage

Query

:SOURce?		Query frequency input source
Short-form format:	:freq:sour?	
Response message:	CURR or VOLT	

Description

This command is used to select the input source for the signal to be measured. If connecting a current signal to the Model 2001 (AMPS and LO INPUT terminals), select the CURRent input source. If connecting a voltage signal (HI and LO INPUT terminals), select the VOLTage input source.

Programming example

```
10  OUTPUT 716; ":freq:sour  curr; sour?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects the current input source, and second queries the input source.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the input source (CURR).

4.19.17 THReshold commands

:RANGe <n>

[:SENSe[1]]:FREQuency:THReshold:CURRent:RANGe <n> Set current threshold range
[:SENSe[1]]:FREQuency:THReshold:VOLTage:RANGe <n> Set voltage threshold range

Parameters

<n>	= 0 to 1	Specify signal level in amps (current threshold)
	= 0 to 1000	Specify signal level in volts (voltage threshold)
	= DEFault	1mA maximum signal level (current threshold)
		10V maximum signal level (voltage threshold)
	= MINimum	1mA maximum signal level (current threshold)
		1V maximum signal level (voltage threshold)
	= MAXimum	1A maximum signal level (current threshold)
		1000V maximum signal level (voltage threshold)

Formats

:freq:thr:curr:rang <n>
:freq:thr:volt:rang <n>

Defaults

Power-up	Saved power-on setup
*RST	1mA maximum signal level
	10V maximum signal level
:SYSTem:PRESet	1mA maximum signal level
	10V maximum signal level

Query

:RANGe?	Query maximum signal level
:RANGe? DEFault	Query *RST default signal level
:RANGe? MINimum	Query the lowest allowable signal level
:RANGe? MAXimum	Query the largest allowable signal level

Short-form formats:
:freq:thr:curr:rang?
:freq:thr:curr:rang? xxx
:freq:thr:volt:rang?
:freq:thr:volt:rang? xxx
where; xxx = def, min or max

Response message:

0.001 (1mA)	1 (1V)
0.01 (10mA)	10 (10V)
0.1 (100mA)	100 (100V)
1 (1A)	1000 (1000V)

Description

These commands are used to specify the expected input level. The instrument will then automatically select the most sensitive current or voltage threshold range. For example, if you specify the expected input current to be 20mA, the instrument will automatically select the 100mA current threshold range.

Programming example

```
10  OUTPUT 716; ":freq:thr:curr:rang  150e-3; rang?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Specifies the the expected input signal to be 150mA and then queries the current threshold range.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the current threshold range (1).

:LEVel <n>

[:SENSe[1]]:FREQuency:THReshold:CURRent:LEVel <n> Set current threshold level
[:SENSe[1]]:FREQuency:THReshold:VOLTage:LEVel <n> Set voltage threshold level

Parameters

Current Threshold:

<n>	= -0.0006 to +0.0006	Trigger level for 1mA range
	= -0.006 to +0.006	Trigger level for 10mA range
	= -0.06 to +0.06	Trigger level for 100mA range
	= -0.6 to +0.6	Trigger level for 1A range
	= DEFault	0A trigger level
	= MINimum	Range dependent as shown above
	= MAXimum	Range dependent as shown above

Voltage Threshold:

<n>	= -0.6 to +0.6	Trigger level for 1V range
	= -6 to +6	Trigger level for 10V range
	= -60 to +60	Trigger level for 100V range
	= -600 to +600	Trigger level for 1000V range
	= DEFault	0V trigger level
	= MINimum	Range dependent as shown above
	= MAXimum	Range dependent as shown above

Formats

:freq:thr:curr:lev <n>
:freq:thr:volt:lev <n>

Defaults

Power-up	Saved power-on setup
*RST	0 (volts and amps)
:SYSTem:PRESet	0 (volts and amps)

Query

:LEVel?	Query trigger level
:LEVel? DEFault	Query *RST default trigger level
:LEVel? MINimum	Query lowest allowable trigger level
:LEVel? MAXimum	Query largest allowable trigger level
Short-form formats:	:freq:thr:curr:lev? :freq:thr:volt:lev? xxx :freq:thr:volt:lev? :freq:thr:volt:lev? xxx where; xxx = def, min or max
Response messages:	-0.6 to +0.6 (amps; current threshold) -600 to +600 (volts; voltage threshold)

Description

These commands are used to specify threshold trigger levels for the specified (current or voltage) input signal. An appropriate trigger level is necessary in order for the frequency counter to operate properly. The instrument will only count cycles whose peak signal amplitude reaches the programmed trigger level. For example, if you have the trigger set for 0.5mA, cycles whose peak amplitude is less than 0.5mA will not be counted.

If using AC+DC coupling (see :COUPling), make sure that the threshold signal level accounts for the DC bias level. For example, if a 10mA peak-to-peak input signal is riding on a 50mA DC bias level, a threshold signal level of 55mA would be appropriate. Notice that the range of valid parameter values depends on which threshold range is selected (see :RANGe). As a general rule, the limit value can be up to +/- 60% of the programmed threshold range.

Programming example

```
10  OUTPUT 716; ":freq:thr:curr:rang  .01; lev .005; lev?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects the 10mA current threshold range, specifies a 5mA trigger level, and then queries the trigger level.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the trigger level (0.005).

:TTL

[:SENSe[1]]:FREQuency:THReshold:VOLTage:TTL Select TTL trigger level

Format

:freq:thr:volt:ttl

Description

This action command is used to configure the voltage threshold trigger level for a TTL input signal. After this command is sent, the 10V threshold voltage range will be selected and a threshold trigger level of 0.8V will be established.

Programming example

```
10  OUTPUT 716; ":freq:thr:volt:ttl"
20  OUTPUT 716; ":freq:thr:volt:rang?; lev?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Program the voltage threshold for TTL signal levels.
Line 20 Queries the threshold voltage range, and then queries the trigger level.
Line 30 Addresses the Model 2001 to talk.
Line 40 Displays the threshold voltage range and trigger level (10; 0.8).

4.19.18 :TRANsducer <name>

[:SENSe[1]]:TEMPerature:TRANsducer <name> Specify transducer type

Parameters

<name>	= RTD	Two-wire RTD transducer
	= FRTD	Four-wire (and three-wire) RTD transducer
	= TCouple	Thermocouple transducer

Format

:temp:tran <name>

Defaults

Power-up	Saved power-on setup
*RST	FRTD transducer
:SYSTem:PRESet	FRTD transducer

Query

:TRANsducer?	Query transducer type
Short-form format:	:temp:tran?
Response message:	RTD, FRTD or TC

Description

This command is used to program the instrument for the transducer type that you are using. If using a two-wire RTD transducer, select RTD. If using a three-wire or four-wire RTD, select FRTD. If using a thermocouple, select TCouple.

Programming example

```
10  OUTPUT 716; ":temp:tran  frtd; tran?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first programs the Model 2001 for FRTD temperature measurements, and the second queries the transducer type.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the transducer type (FRTD).

4.19.19

:RTD commands

:TYPE <name>

[:SENSe[1]]:TEMPerature:RTD:TYPE <name> Set RTD parameters

Parameters

<name>	= PT385	Selects default parameters for 0.00385 standard
	= PT3916	Selects default parameters for 0.003916 standard
	= USER	Selects user-defined parameters

Format :temp:rtd:type <name>

Defaults

Power-up	Saved power-on setup
*RST	PT385
:SYSTem:PRESet	PT385

Query

:TYPE?	Query RTD type
Short-form format:	:temp:rtd:type?
Response message:	PT385, PT3916 or USER

Description This command is used to select the RTD standard and the other related factors. When PT385 or PT3916 is selected, the instrument defaults to the following RTD factors:

Type	Alpha	Beta	Delta	Ω at 0°C
PT385	0.003850	0.111	1.50700	100Ω
PT3916	0.003916	0.116	1.50594	100Ω

Changing Alpha (see :ALPHa), Beta (see :BETA), Delta (see :DELTa) or Ω at 0°C (see :RZERo) automatically changes the Type to USER (:TYPE USER). Thus, once you program the appropriate factors for your RTD, you can later recall that setup by using the :TYPE USER command.

Programming example

```
10  OUTPUT 716; ":temp:rtd:type  pt385; type?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first programs the RTD factors to the PT385 defaults, and the second queries the Type.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays Type (PT385).

:ALPHa <NRf>

[:SENSe[1]]:TEMPerature:RTD:ALPHa <NRf> Specify Alpha value

Parameter <NRf> = 0 to 0.01 Specify RTD Alpha value

Format :temp:rtd:alph <NRf>

Defaults

Power-up	Saved power-on setup
*RST	Alpha = 0.00385
:SYSTem:PRESet	Alpha = 0.00385

Query

:ALPHa?	Query the Alpha value
Short-form format:	:temp:rtd:alph?
Response message:	0 to 0.01

This command is used to check and/or change the Alpha value. Keep in mind that changing the current Alpha value changes the Type to USER (see :RTD:TYPE).

Programming example

```
10  OUTPUT 716; ":temp:rtd:alph  0.0035; alph?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first changes the Alpha value to 0.0035, and the second queries the Alpha value.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the Alpha value (0.0035).

:BETA <NRf>

[:SENSe[1]]:TEMPerature:RTD:BETA <NRf> Specify Beta value

Parameter <NRf> = 0 to 1 Specify RTD Beta value

Format :temp:rtd:beta <NRf>

Defaults

Power-up	Saved power-on setup
*RST	Beta = 0.111
:SYSTem:PRESet	Beta = 0.111

Query

:BETA?	Query the Beta value
Short-form format:	:temp:rtd:beta?
Response message:	0 to 1

Description This command is used to check and/or change the Beta value. Keep in mind that changing the current Beta value changes the Type to USER (see :RTD:TYPE).

Programming example

```
10  OUTPUT 716; ":temp:rtd:beta  0.11; beta?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first changes the Beta value to 0.11, and the second queries the Beta value.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the Beta value (0.11).

:DELTa <NRf>

[:SENSe[1]]:TEMPerature:RTD:DELTa <NRf> Specify Delta value

Parameter <NRf> = 0 to 5 Specify RTD Delta value

Format :temp:rtd:delt <NRf>

Defaults

Power-up	Saved power-on setup
*RST	Delta = 1.507
:SYSTem:PRESet	Delta = 1.507

Query

:DELTa?	Query the Delta value
Short-form format:	:temp:rtd:delt?
Response message:	0 to 5

Description This command is used to check and/or change the Delta value. Keep in mind that changing the current Delta value changes the Type to USER (see :RTD:TYPE).

Programming example

```
10  OUTPUT 716; ":temp:rtd:delt  1.75; delt?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first changes the Delta value to 1.75, and the second queries the Delta value.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the Delta value (1.75).

:RZERo <NRf>

[:SENSe[1]]:TEMPerature:RTD:RZERo <NRf> Specify resistance at 0°C

Parameter <NRf> = 0 to 1000 Specify RTD Resistance at 0°C (in ohms)

Format :temp:rtd:rzer <NRf>

Defaults

Power-up	Saved power-on setup
*RST	Resistance at 0°C = 100Ω
:SYSTem:PRESet	Resistance at 0°C = 100Ω

Query

:RZERo?	Query RTD resistance at °C
Short-form format:	:temp:rtd:rzer?
Response message:	0 to 1000

Description This command is used to check and/or change the Resistance at 0°C. Keep in mind that changing the current resistance value changes the Type to USER (see :RTD:TYPE).

Programming example

```
10  OUTPUT 716; ":temp:rtd:rzer  200; rzer?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first changes the resistance value to 200Ω, and the second queries the resistance value.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the resistance value (200).

4.19.20 :SPRTD commands

[:SENSe[1]]:TEMPerature:SPRTD:RZERo <NRf>
[:SENSe[1]]:TEMPerature:SPRTD:A4 <NRf>
[:SENSe[1]]:TEMPerature:SPRTD:B4 <NRf>
[:SENSe[1]]:TEMPerature:SPRTD:A7 <NRf>
[:SENSe[1]]:TEMPerature:SPRTD:B7 <NRf>
[:SENSe[1]]:TEMPerature:SPRTD:C7 <NRf>

Parameters

:RZERo <NRf>	Set RTD 0°C resistance value
:A4 <NRf>	Set A4 coefficient
:B4 <NRf>	Set B4 coefficient
:A7 <NRf>	Set A7 coefficient
:B7 <NRf>	Set B7 coefficient
:C7 <NRf>	Set C7 coefficient

Query

:RZERo?	Query RTD 0°C resistance value
:A4?	Query A4 coefficient
:B4?	Query B4 coefficient
:A7?	Query A7 coefficient
:B7?	Query B7 coefficient
:C7?	Query C7 coefficient

Description These commands program the various parameters for SPRTD (Standard Platinum Resistance Thermometers). A single SPRTD, however, usually cannot be used to cover the entire range, so the temperature range is broken up into several subranges. An SPRTD is supplied with a certificate of calibration that lists the calibration constants and the temperature range supported. In most cases, the supplied coefficients must be translated into Model 2001 values as summarized in the table below. See paragraph 3.4.5 in Section 3 for more information.

Table 4-26
RTD coefficients to Model 2001 coefficients

Coefficients	RTD coefficients to Model 2001 coefficients
Subrange #1: 13.8033K - 273.16K	Not applicable
Subrange #2: 24.5561K - 273.16K	A2 to A4, B2 to B4
Subrange #3: 54.3584K - 273.16K	A3 to A4, B3 to B4
Subrange #4: 83.8058K - 273.16K	No substitution needed
Subrange #5: 234.3156K - 302.9146K	A5 to A4, A5 to A7, B5to B4, B5 to B7, Set C7 = 0. A5 value entered for both A4 and A7, B5 entered for both B4 and B7.
Subrange #6: 273.15K - 1234.93K	Not applicable
Subrange #7: 273.15K - 933.473K	No substitution needed
Subrange #8: 273.15K - 692.677K	A8 to A7, B8 to B7, Set C7 = 0
Subrange #9: 273.15K - 505.078K	A9 to A7, B9 to B7, Set C7 = 0
Subrange #10: 273.15K - 429.748K	A10 to A7, B10 to B7, Set C7 = 0
Subrange #11: 273.15K - 302.9146K	A11 to A7, Set B7 = 0, C7 = 0

Programming example

Suppose you are using an SPRTD that has been calibrated for subrange #2 above that is calibrated for measurements between 24.5561 and 273.16K. Model 2001, however supports only SPRTD temperatures down to 83.805K, so temperatures below this value will be reported as an overflow even though the SPRTD is capable of measuring lower. The calibration certificate lists A2, B2, C1, C2, and C3 as the calibration coefficients. You can set up Model 2001 for this measurement as follows:

1. Set the temperature sensor type to FRTD (4-wire measurement) by sending:
   :SENS1:TEMP:TRAN FRTD
2. Choose the RTD type as SPRTD:
   :SENS1:TEMP:RTD:TYPE SPRTD
3. Set the RTD sensor 0°C resistance value:
   :SENS1:TEMP:RTD:SPRTD:RZER <R_zero>
4. Set the A4 coefficient to the RTD certificate value for A2:
   :SENS1:TEMP:SPRTD:A4 <certificate_A2_value>
5. Set the B4 coefficient to the RTD certificate value for B2:
   :SENS1:TEMP:SPRTD:B4 <certificate_B2_value>

Note that the A7, B7, and C7 values will not be used for this sensor.

6. Change to the temperature function, and begin taking readings.

4.19.21 :TCouple:TYPE <name>

[:SENSe[1]]:TEMPerature:TCouple:TYPE <name> Specify TC type

Parameters

<name>	= J	Set operation for Type J thermocouples
	= T	Set operation for Type T thermocouples
	= K	Set operation for Type K thermocouples
	= E	Set operation for Type E thermocouples
	= R	Set operation for Type R thermocouples
	= S	Set operation for Type S thermocouples
	= B	Set operation for Type B thermocouples
	= N	Set operation for Type N thermocouples

Format

:temp:tc:type <name>

Defaults

Power-up	Saved power-on setup
*RST	Type J
:SYSTem:PRESet	Type J

Query

:TYPE?	Query thermocouple type
Short-form format:	:temp:tc:type?
Response message:	J, T, K, E, R, S, B, or N

Description

This command is used to configure the Model 2001 for the thermocouple type that you are using to make temperature measurements.

Programming example

```
10  OUTPUT 716; ":temp:tc:type  k; type?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first configures operation for Type K thermocouples, and the second queries the thermocouple type.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the thermocouple type (K).

4.19.22 :RJUNctionX

[:SENSe[1]]:TEMPerature:RJUNctionX

Parameter X= 1 to 5 Specify reference junction

Description Used to configure the specified reference junction for thermocouple temperature measurements. Typically, each thermocouple switching card uses a single reference junction.

:RSELect <name>

[:SENSe[1]]:TEMPerature:RJUNctionX:RSELect <name> Specify reference junction type

Parameters
<name> = SIMulated Use simulated temperature as reference
= REAL Use a measured temperature as reference

Format
:temp:rjunX:rsel <name>
where; X = 1 to 5 (reference junction #)

Defaults
Power-up Saved power-on setup
*RST SIMulated
:SYSTem:PRESet SIMulated

Query
:RSELect? Query reference junction type
Short-form format: :temp:rjunX:rsel?
where; X = 1 to 5 (reference junction #)
Response message: SIM or REAL

Description This command is used to specify the type of reference junction that is going to be used for thermocouple temperature measurements. Specify REAL if using an actual reference junction. The :REAL:TCoefficient command is then used to specify the temperature coefficient of the reference junction.

Specify SIMulated if you wish to use a simulated reference temperature. The :SIMulated command is then used to specify the desired simulated reference temperature.

Programming example

```
10 OUTPUT 716; ":temp:rjun1:rsel sim; rsel?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Two commands in this program message; the first selects a simulated reference for reference junction #1, and the second queries the reference type.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the reference type for reference junction #1 (SIM).

:SIMulated <n>

[:SENSe[1]]:TEMPerature:RJUNctionX:SIMulated <n> Specify simulated reference temperature

Parameters

<n>	= 0 to 50	Specify temperature in °C
	= 32 to 122	Specify temperature in °F
	= 273 to 323	Specify temperature in K
	= DEFault	23°C, 73.4°F, 296K
	= MINimum	0°C, 32°F, 273K
	= MAXimum	50°C, 122°F, 323K

Format

:temp:rjunX:sim <n>
where; X = 1 to 5 (reference junction #)

Defaults

Power-up	Saved power-on setup
*RST	23°C
:SYSTem:PRESet	23°C

Query

:SIMulated?	Query simulated reference
:SIMulated? DEFault	Query default *RST reference
:SIMulated? MINimum	Query lowest allowable reference
:SIMulated? MAXimum	Query largest allowable reference
Short-form formats:	:temp:rjunX:sim?
	:temp:rjunX:sim? def
	:temp:rjunX:sim? min
	:temp:rjunX:sim? max
	where; X = 1 to 5 (reference junction #)
Response message:	Reference temperature

Description

This command is used to specify the simulated reference temperature. The temperature value depends on which temperature scale is currently selected (°C, °F or K). Typically, 0° or 23°C is used as the simulated reference temperature.

The :ACQuire command is then used to store the simulated reference temperature.

Programming example

```
10  OUTPUT 716; ":unit:temp c"
20  OUTPUT 716; ":temp:rjun1:sim  0; sim?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Selects °C temperature scale.

Line 20 Two commands in this program message; the first programs reference junction #1 for a 0°C simulated reference temperature, and the second queries the simulated reference temperature.

Line 30 Addresses the Model 2001 to talk.

Line 40 Displays the simulated reference temperature (0)

4.19.23

:REAL commands

:TCOefficient <n>

[:SENSe[1]]:TEMPerature:RJUNctionX:REAL:TCOefficient <n> Specify temperature coefficient

Parameters

<n>	= -0.09999 to +0.09999	Specify temperature coefficient
	= DEFault	+0.01 temperature coefficient
	= MINimum	-0.09999 temperature coefficient
	= MAXimum	+0.09999 temperature coefficient

Format

:temp:rjunX:real:tco <n>
where; X = 1 to 5 (reference junction #)

Defaults

Power-up	Saved power-on setup
*RST	0.01 temperature coefficient
:SYSTem:PRESet	0.01 temperature coefficient

Query

:TCOefficient?	Query temperature coefficient (TC)
:TCOefficient? DEFault	Query *RST default TC
:TCOefficient? MINimum	Query lowest allowable TC
:TCOefficient? MAXimum	Query largest allowable TC
Short-form format:	:temp:rjunX:real:tco?
	:temp:rjunX:real:tco? def
	:temp:rjunX:real:tco? min
	:temp:rjunX:real:tco? max
	where; X = 1 to 5 (reference junction #)
Response message:	-0.09999 to +0.09999

Description

This command is used to specify the temperature coefficient (TC) of the "real" temperature reference junction. TC is specified in °C/volt and is not affected by the :UNIT :TEMPerature command. The :ACQuire command can then be used to acquire the reference temperature.

Programming example

```
10  OUTPUT 716; ":temp:rjun1:real:tco  0.05; tco?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first specifies a TC of 0.05 for reference junction #1, and the second queries the TC.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the TC (0.05).

:OFFSet <n>

[:SENSe[1]]:TEMPerature:RJUNctionX:REAL:OFFSet <n> Specify voltage offset

Parameters

<n>	= -0.09999 to +0.09999	Specify voltage offset at 0°C
	= DEFault	0.01V offset
	= MINimum	-0.09999V offset
	= MAXimum	+0.09999V offset

Format

:temp:rjunX:real:offs <n>
where; X = 1 to 5 (reference junction #)

Defaults

Power-up	Saved power-on setup
*RST	0.01V offset
:SYSTem:PRESet	0.01V offset

Query

:OFFSet?	Query voltage offset
:OFFSet? DEFault	Query *RST default voltage offset
:OFFSet? MINimum	Query lowest allowable voltage offset
:OFFSet? MAXimum	Query largest allowable voltage offset
Short-form format:	:temp:rjunX:real:offs?
	:temp:rjunX:real:offs? def
	:temp:rjunX:real:offs? min
	:temp:rjunX:real:offs? max
	where; X = 1 to 5 (reference junction #)
Response message:	-0.09999 to +0.09999

Description

This command is used to specify the offset voltage at 0°C for the specified reference junction.

Programming example

```
10  OUTPUT 716; ":temp:rjunX:real:offs  0.05; offs?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first specifies an offset of 50mV, and the second queries the offset.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the offset (0.05).

:ACQuire

[:SENSe[1]]:TEMPerature:RJUNctionX:ACQuire Update reference temperature

Description

This action command is used to update the stored reference temperature (Simulated or Real) for generating a temperature measurement.

Programming example

```
OUTPUT 716; ":temp:rjun1:acq"    ! Update reference temperature
```

4.19.24 :OCOMpensated <b>

[:SENSe[1]]:RESistance:OCOMpensated <b> Control offset compensation for Ω2
[:SENSe[1]]:FRESistance:OCOMpensated <b> Control offset compensation for Ω4

Parameters

<b>	= 0 or OFF	Disable offset compensated ohms
	= 1 or ON	Enable offset compensated ohms

Formats

:res:ocom <b>
:fres:ocom <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:OCOMpensated?	Query state of offset compensated ohms
Short-form format:	:res:ocom?
	:fres:ocom?
Response message:	1 (on) or 0 (off)

Description

This command is used to enable or disable the offset compensated ohms feature. Offset compensation is used to cancel the effects of offset voltages (such as thermal EMFs) when making resistance measurements. Offset compensation is explained in detail in the front panel operation section of this manual.

Programming example

```
10  OUTPUT 716; ":res:ocom  on; ocom?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first enables offset compensation and, the second queries the state of offset compensation.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of offset compensation (1; on).

4.19.25 :SENSe2 subsystem

This subsystem is used read the digital I/O port.

:TTL[1]:DATA?

:SENSe2:TTL[1]:DATA? Read input port

Format :sens2:ttl:data?

Description This command is used to read the single line of the digital input port. After sending this command and addressing the Model 2001 to talk, a value indicating the status of the port will be sent to the computer.

A value of "1" indicates that the input port is high (ON), and a value of "0" indicates that the port is low (OFF).

Programming example

```
10  OUTPUT 716; ":sens2:ttl:data?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Read the input port.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the status of the input port (0 or 1).

4.20 :SOURce subsystem

This subsystem is used to set the logic level (true or false) of each digital output line. The commands for this subsystem are summarized in Table 4-27.

Table 4-27
SOURce command summary

Command	Description
:SOURce	
:TTL[1][:LEVel] <b>	Set digital output line #1 true (1 or ON) or false (0 or OFF).
:TTL[1][:LEVel]?	Query digital output line 1.
:TTL2[:LEVel] <b>	Set digital output line #2 true (1 or ON) or false (0 or OFF).
:TTL2[:LEVel]?	Query digital output line 2.
:TTL3[:LEVel] <b>	Set digital output line #3 true (1 or ON) or false (0 or OFF).
:TTL3[:LEVel]?	Query digital output line 3.
:TTL4[:LEVel] <b>	Set digital output line #4 true (1 or ON) or false (0 or OFF).
:TTL4[:LEVel]?	Query digital output line 4.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. If a LIMITS control is enabled (LOLIM1 or 2, HILIM1 or 2 — High, Low, or Pass), this command does not check or change the output status. Refer to paragraph 3.12.5 for information on limits.

[:LEVel] <b>

:SOURce:TTL[1]:[LEVel] <b>	Control digital output line #1
:SOURce:TTL2:[LEVel] <b>	Control digital output line #2
:SOURce:TTL3:[LEVel] <b>	Control digital output line #3
:SOURce:TTL4:[LEVel] <b>	Control digital output line #4

Parameters

<b>	= 1 or ON	Set output line true
	= 0 or OFF	Set output line false

Formats

:sour:ttl <b>
:sour:ttl2 <b>
:sour:ttl3 <b>
:sour:ttl4 <b>

Defaults

Power-up	OFF (all lines)
*RST	No effect
:SYSTem:PRESet	No effect

Query

:LEVel]?	Query logic level of specified line	
Short-form formats:	:sour:ttl?	:sour:ttl2?
	:sour:ttl3?	:sour:ttl4?
Response message:	0 (false) or 1 (true)	

Description

These commands are used to set the logic levels for the digital output port. The actual level (high or low) of a digital output line depends on its programmed polarity (see Output subsystem). If the polarity of a line is active-high, then that line will be high when it is set to be true (1 or ON), and low when it is set to be false (0 or OFF). Conversely, if polarity is active-low, the line will be low when it is set to be true, and high when it is set to be false.

Programming example

```
10  OUTPUT 716; ":sour:ttl   on; ttl?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets output line #1 to true, and then queries the state of the output line.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of output line #1 (1; on).

4.21 :STATus subsystem

The STATus subsystem is used to control the status registers of the Model 2001. These registers and the overall status structure is explained in paragraph 4.6.

The commands in this subsystem are summarized in Table 4-28.

Table 4-28
STATus command summary

Command	Description	Reference
:STATus		
:MEASurement	Path to control measurement event registers:	
[:EVENt]?	Read the event register.	4.21.1
:ENABle <NRf>	Program the enable register.	4.21.2
:ENABle?	Read the enable register.	
:PTRansition <NRf>	Program the positive transition register.	4.21.3
:PTRansition?	Read the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	4.21.4
:NTRansition?	Read the negative transition register.	
:CONDition?	Read the condition register.	4.21.5
:OPERation	Path to control operation event registers:	
[:EVENt]?	Read the event register.	4.21.1
:ENABle <NRf>	Program the enable register.	4.21.2
:ENABle?	Read the enable register.	
:PTRansition <NRf>	Program the positive transition register.	4.21.3
:PTRansition?	Read the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	4.21.4
:NTRansition?	Read the negative transition register.	
:CONDition?	Read the condition register.	4.21.5
:ARM	Path to control arm event registers:	
[:EVENt]?	Read the event register.	4.21.1
:ENABle <NRf>	Program the enable register.	4.21.2
:ENABle?	Read the enable register.	
:PTRansition <NRf>	Program the positive transition register.	4.21.3
:PTRansition?	Read the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	4.21.4
:NTRansition?	Read the negative transition register.	
:CONDition?	Read the condition register.	4.21.5
:SEQuence	Path to control the sequence event registers:	
[:EVENt]?	Read the event register.	4.21.1
:ENABle <NRf>	Program the enable register.	4.21.2
:ENABle?	Read the enable register.	
:PTRansition <NRf>	Program the positive transition register.	4.21.3
:PTRansition?	Read the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	4.21.4
:NTRansition?	Read the negative transition register.	
:CONDition?	Read the condition register.	4.21.5

Table 4-28 (cont.)
STATus command summary

Command	Description	Reference
:STATus		
:OPERation		
:TRIGger	Path to control trigger event registers:	
[:EVENt]?	Read the event register.	4.21.1
:ENABle <NRf>	Program the enable register.	4.21.2
:ENABle?	Read the enable register.	
:PTRansition <NRf>	Program the positive transition register.	4.21.3
:PTRansition?	Read the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	4.21.4
:NTRansition?	Read the negative transition register.	
:CONDition?	Read the condition register.	4.21.5
:QUEStionable	Path to control questionable event registers:	
[:EVENt]?	Read the event register.	4.21.1
:ENABle <NRf>	Program the enable register.	4.21.2
:ENABle?	Read the enable register.	
:PTRansition <NRf>	Program the positive transition register.	4.21.3
:PTRansition?	Read the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	4.21.4
:NTRansition?	Read the negative transition register.	
:CONDition?	Read the condition register.	4.21.5
:PRESet	Return status registers to default states.	4.21.6
:QUEue	Path to access error queue:	4.21.7
[:NEXT]?	Read the most recent error message.	
:ENABle <list>	Specify error and status messages for queue.	
:ENABle?	Read the enabled messages.	
:DISable <list>	Specify messages not to be placed in queue.	
:DISable?	Read the disabled messages.	
:CLEar	Clears all messages from Error Queue.	

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.21.1 :EVENt]?

:STATus:MEASurement[:EVENt]? Read Measurement Event Register
:STATus:QUEStionable[:EVENt]? Read Questionable Event Register
:STATus:OPERation[:EVENt]? Read Operation Event Register
:STATus:OPERation:TRIGger[:EVENt]? Read Trigger Event Register
:STATus:OPERation:ARM[:EVENt]? Read Arm Event Register
:STATus:OPERation:ARM:SEQuence[:EVENt]? Read Sequence Event Register

Formats

```
:stat:meas?
:stat:ques?
:stat:oper?
:stat:oper:trig?
:stat:oper:arm?
:stat:oper:arm:seq?
```

Defaults

Power-up	Clears (0) all bits
*CLS	Clears (0) all bits
:STATus:PRESet	No effect

Description

These query commands are used to read the event registers. After sending one of these commands and addressing the Model 2001 to talk, a decimal value is sent to the computer. The binary equivalent of this value determines which bits in the appropriate register are set. The event registers are shown in Figures 4-22 through 4-27. Note that reading an event register clears the bits in that register.

For example, assume that reading the Measurement Event Register results in an acquired decimal value of 544. The binary equivalent is 0000001000100000. For this binary value, bits B5 and B9 of the Measurement Event Register are set.

The significance of a set bit in these registers depends on how the transition filter is programmed (see :PTRansition and :NTRansition commands). If an event is programmed for a positive transition (PTR), the corresponding bit in this register will set when the event occurs. If the event is instead programmed for a negative transition (NTR), the bit will set when the event becomes not true.

Measurement Event Register:

Bit B0, Reading Overflow (ROF) — Set bit indicates that the reading exceeds the measurement range of the instrument (PTR), or the instrument has gone from an overflow condition to a normal reading condition (NTR).

Bit B1, Low Limit 1 (LL1) — Set bit indicates that the reading is less than the Low Limit 1 setting (PTR), or that a subsequent reading is no longer less than the Low Limit 1 setting (NTR).

Bit B2, High Limit 1 (HL1) — Set bit indicates that the reading is greater than the High Limit 1 setting (PTR), or that a subsequent reading is no longer greater than the High Limit 1 setting (NTR).

Bit B3, Low Limit 2 (LL2) — Set bit indicates that the reading is less than the Low Limit 2 setting (PTR), or that a subsequent reading is no longer less than the Low Limit 2 setting (NTR).

Bit B4, High Limit 2 (HL2) — Set bit indicates that the reading is greater than the High Limit 2 setting (PTR), or that a subsequent reading is no longer greater than the High Limit 2 setting (NTR).

Bit B5, Reading Available (RAV) — Set bit indicates that a reading was taken and processed (PTR), or that a subsequent reading is in process (NTR).

Bit B6 — Not used.

Bit B7, Buffer Available (BAV) — Set bit indicates that there are at least two readings in the trace buffer (PTR), or the buffer has become empty (NTR).

Bit B8, Buffer Half Full (BHF) — Set bit indicates that the trace buffer is half full (PTR), or that the buffer is no longer half full (NTR).

Bit B9, Buffer Full (BFL) — Set bit indicates that the trace buffer is full (PTR), or that the buffer is no longer full (NTR).

Bit B10 — Not used.

Bit B11, Buffer Pretriggered (BPT) — Set bit indicates that the trace buffer pretrigger event has occurred (PTR), or the operations associated with the pretrigger have been completed (NTR).

Bits B12 through B15 — Not used.

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	BPT	—	BFL	BHF	BAV	—	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	——	2048 (2^{11})	—	512 (2^9)	256 (2^8)	128 (2^7)	—	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
Value	——	0/1	—	0/1	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Measurement Event Set
0 = Measurement Event Cleared

Events : BPT = Buffer Pretriggered
BFL = Buffer Full
BHF = Buffer Half Full
BAV = Buffer Available
RAV = Reading Available
HL2 = High Limit 2
LL2 = Low Limit 2
HL1 = High Limit 1
LL1 = Low Limit 1
ROF = Reading Overflow

Figure 4-22
Measurement Event Register

Questionable Event Register:

Bits B0 through B3 — Not used.

Bit B4, Temperature Summary (Temp) — Set bit indicates that an invalid reference junction measurement has occurred for thermocouple temperature measurements (PTR), or a subsequent valid reference junction measurement has occurred (NTR).

Bits B5, B6 and B7 — Not used.

Bit B8, Calibration Summary (Cal) — Set bit indicates that an invalid calibration constant was detected during the power-up sequence (PTR). The instrument will instead use a default calibration constant. This error will clear after successful calibration of the instrument.

Bits B9 through B13 — Not used.

Bit B14, Command Warning (Warn) — Set bit indicates that a Signal Oriented Measurement Command parameter has been ignored (PTR), or a subsequent Signal Oriented Measurement Command has executed successfully (NTR).

Note: Whenever a questionable event occurs, the ERR annunciator will turn on. The annunciator will turn off when the questionable event clears.

Bit Position	B15	B14	B13 - B9	B8	B7 - B5	B4	B3 - B0
Event	—	Warn	——	Cal	——	Temp	——
Decimal Weighting	—	16384 (2^{14})	——	256 (2^8)	——	16 (2^4)	——
Value	0	0/1	——	0/1	——	0/1	——

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : Warn = Command Warning
Cal = Calibration Summary
Temp = Temperature Summary

Figure 4-23
Questionable Event Register

Operation Event Register:

Bit B0, Calibrating (Cal) — Set bit indicates that the instrument is calibrating (PTR), or calibration is complete (NTR).

Bit B1, Settling (Set) — Set bit indicates that the instrument is waiting for signals to settle (PTR), or the settling period has expired (NTR).

Bits B2, B3 and B4 — Not used.

Bit B5, Waiting for Trigger (Trig) — Set bit indicates that the instrument is waiting in the trigger layer (PTR) of the trigger model, or that it has left the trigger layer (NTR).

Bit B6, Waiting for Arm (Arm) — Set bit indicates that the instrument is waiting in an arm layer of the trigger model (PTR), or operation has proceeded from the arm layers into the trigger layer (NTR).

Bits B7 and B8 — Not used.

Bit B9, Calculating (Calc) — Set bit indicates that the instrument is performing a math calculation (PTR) or the calculation is complete (NTR).

Bit B10, Idle — Set bit indicates that the instrument is in the idle state (PTR), or has left the idle state to perform an operation (NTR).

Bits B11 through B15 — Not used.

Bit Position	B15 - B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	Calc	—	—	Arm	Trig	—	—	—	Set	Cal
Decimal Weighting	——	1024 (2^{10})	512 (2^9)	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	1 (2^0)
Value	——	0/1	0/1	—	—	0/1	0/1	—	—	—	0/1	0/1

Value : 1 = Operation Event Set
0 = Operation Event Cleared

Events : Idle = Idle state of the 2001
Calc = Calculating
Arm = Waiting for Arm
Trig = Waiting for Trigger
Set = Settling
Cal = Calibrating

Figure 4-24
Operation Event Register

Trigger Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in the trigger layer (PTR), or that the instrument has exited from the trigger layer (NTR).

Bits B2 through B15 — Not used.

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^1)	—
Value	——	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared
Event : Seq1 = Sequence 1

Figure 4-25
Trigger Event Register

Arm Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in an arm layer (PTR), or that the instrument has exited from the arm layers (NTR).

Bits B2 through B15 — Not used.

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared
Event : Seq1 = Sequence 1

Figure 4-26
Arm Event Register

Sequence Event Register:

Bit B0 — Not used.

Bit B1, Layer 1 (Lay1) — Set bit indicates that instrument operation is in arm layer 1 (PTR), or that operation has exited from arm layer 1 NTR).

Bit B2, Layer 2 (Lay2) — Set bit indicates that instrument operation is in arm layer 2 (PTR), or that operation has exited from arm layer 2 NTR).

Bits B3 through B15 — Not used.

Bit Position	B15 - B3	B2	B1	B0
Event	——	Lay2	Lay1	—
Decimal Weighting	——	4 (22)	2 (21)	—
Value	——	0/1	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared
Event : Lay1 = Layer 1
Lay2 = Layer 2

Figure 4-27
Sequence Event Register

Programming example

```
10 OUTPUT 716; ":stat:meas?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Queries the Measure Event Register.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the decimal value that defines which bits in the register are set.

4.21.2 :ENABle <NRf>

:STATus:MEASurement:ENABle <NRf>	Program Measurement Event Enable Register
:STATus:QUEStionable:ENABle <NRf>	Program Questionable Event Enable Register
:STATus:OPERation:ENABle <NRf>	Program Operation Event Enable Register
:STATus:OPERation:TRIGger:ENABle <NRf>	Program Trigger Event Enable Register
:STATus:OPERation:ARM:ENABle <NRf>	Program Arm Event Enable Register
:STATus:OPERation:ARM:SEQuence:ENABle <NRf>	Program Sequence Event Enable Register

Parameters

<NRf>	= 0	Clear enable register
	= 1	Set bit B0 of enable register
	= 2	Set bit B1 of enable register
	= 4	Set bit B2 of enable register
	= 8	Set bit B3 of enable register
	= 16	Set bit B4 of enable register
	= 32	Set bit B5 of enable register
	= 64	Set bit B6 of enable register
	= 128	Set bit B7 of enable register
	= 256	Set bit B8 of enable register
	= 512	Set bit B9 of enable register
	= 1024	Set bit B10 of enable register
	= 2048	Set bit B11 of enable register
	= 16384	Set bit B14 of enable register

Formats

:stat:meas:enab <NRf>
:stat:ques:enab <NRf>
:stat:oper:enab <NRf>
:stat:oper:trig:enab <NRf>
:stat:oper:arm:enab <NRf>
:stat:oper:arm:seq <NRf>

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query

:ENABle?	Query enable register
Short-form formats:	:stat:meas:enab?
	:stat:ques:enab?
	:stat:oper:enab?
	:stat:oper:trig:enab?
	:stat:oper:arm:enab?
	:stat:oper:arm:seq?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 516, the binary equivalent is 0000001000000100. For this binary value, bits B9 and B2 are set.

Description

These commands are used to set the contents of the event enable registers (see Figures 4-28 through 4-33). An :ENABle command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the appropriate register.

Each event enable register is used as a mask for events (see [:EVENt] for descriptions of events). When a bit in an event enable register is cleared (0), the corresponding bit in the event register is masked and thus, cannot set the corresponding summary bit of the next register set in the status structure. Conversely, when a bit in an event enable register is set (1), the corresponding bit in the event register is unmasked. When the unmasked bit in the event register sets, the summary bit of the next register set in the status structure will set.

The decimal weighting of the bits for each event enable register are included in Figures 4-28 through 4-33. The sum of the decimal weights of the bits that you wish to set is sent as the parameter (<NRf>) for the appropriate :ENABle command. For example, to set the BFL and RAV bits of the Measurement Event Enable Register, send the following command:

:stat:meas:enab 544

where;

BFL (bit B9) = Decimal	512
RAV (bit B5) = Decimal	32
<NRf> =	544

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	BPT	—	BFL	BHF	BAV	—	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	——	2048 (2^{11})	—	512 (2^9)	256 (2^8)	128 (2^7)	—	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	2 (2^1)	1 (2^0)
Value	——	0/1	—	0/1	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Enable Measurement Event
0 = Disable (Mask) Measurement Event

Events : BPT = Buffer Pretriggered
BFL = Buffer Full
BHF = Buffer Half Full
BAV = Buffer Available
RAV = Reading Available
HL2 = High Limit 2
LL2 = Low Limit 2
HL1 = High Limit 1
LL1 = Low Limit 1
ROF = Reading Overflow

Figure 4-28
Measurement Event Enable Register

Bit Position	B15	B14	B13 - B9	B8	B7 - B5	B4	B3 - B0
Event	—	Warn	——	Cal	——	Temp	——
Decimal Weighting	—	16384 (2^{14})	——	256 (2^{8})	——	16 (2^{4})	——
Value	0	0/1	——	0/1	——	0/1	——

Value : 1 = Enable Questionable Event
0 = Disable (Mask) Questionable Event

Events : Warn = Command Warning
Cal = Calibration Summary
Temp = Temperature Summary

Figure 4-29
Questionable Event Enable Register

Bit Position	B15 - B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	Calc	—	—	Arm	Trig	—	—	—	Set	Cal
Decimal Weighting	——	1024 (2^{10})	512 (2^{9})	—	—	64 (2^{6})	32 (2^{5})	—	—	—	2 (2^{1})	1 (2^{0})
Value	——	0/1	0/1	—	—	0/1	0/1	—	—	—	0/1	0/1

Value : 1 = Enable Operation Event
0 = Disable (Mask) Operation Event

Events : Idle = Idle state of the 2001
Calc = Calculating
Arm = Waiting for Arm
Trig = Waiting for Trigger
Set = Settling
Cal = Calibrating

Figure 4-30
Operation Event Enable Register

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^1)	—
Value	——	0/1	—

Value : 1 = Enable Trigger Event
0 = Disable (Mask) Trigger Event

Event : Seq1 = Sequence 1

Figure 4-31
Trigger Event Enable Register

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^1)	—
Value	——	0/1	—

Value : 1 = Enable Arm Event
0 = Disable (Mask) Arm Event

Event : Seq1 = Sequence 1

Figure 4-32
Arm Event Enable Register

Bit Position	B15 - B3	B2	B1	B0
Event	——	Lay2	Lay1	—
Decimal Weighting	——	4 (2^2)	2 (2^1)	—
Value	——	0/1	0/1	—

Value : 1 = Enable Sequence Event
0 = Disable (Mask) Sequence Event

Events : Lay1 = Layer 1
Lay2 = Layer 2

Figure 4-33
Sequence Event Enable Register

Programming example

```
10  OUTPUT 716; ":stat:oper:enab  514; enab?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets Bits B1 and B9 of the Operation Event Enable Register, and then queries the register.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set (514).

4.21.3 :PTRansition <NRf>

:STATus:MEASurement:PTRansition <NRf>	Program Measurement Transition Filter (PTR)
:STATus:QUEStionable:PTRansition <NRf>	Program Questionable Transition Filter (PTR)
:STATus:OPERation:PTRansition <NRf>	Program Operation Transition Filter (PTR)
:STATus:OPERation:TRIGger:PTRansition <NRf>	Program Trigger Transition Filter (PTR)
:STATus:OPERation:ARM:PTRansition <NRf>	Program Arm Transition Filter (PTR)
:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>	Program Sequence Transition Filter (PTR)

Parameters

<NRf>	= 0	Clear PTR register
	= 1	Set bit B0 of PTR registe
	= 2	Set bit B1 of PTR register
	= 4	Set bit B2 of PTR register
	= 8	Set bit B3 of PTR register
	= 16	Set bit B4 of PTR register
	= 32	Set bit B5 of PTR register
	= 64	Set bit B6 of PTR register
	= 128	Set bit B7 of PTR register
	= 256	Set bit B8 of PTR register
	= 512	Set bit B9 of PTR register
	= 1024	Set bit B10 of PTR register
	= 2048	Set bit B11 of PTR register
	= 16384	Set bit B14 of PTR register

Formats

```
:stat:meas:ptr  <NRf>
:stat:ques:ptr  <NRf>
:stat:oper:ptr  <NRf>
:stat:oper:trig:ptr  <NRf>
:stat:oper:arm:ptr  <NRf>
:stat:oper:arm:seq:ptr  <NRf>
```

Defaults

Power-up	Sets (1) all bits
*CLS	No effect
:STATus:PRESet	Sets (1) all bits

Query

:PTRansition?	Query PTR register
Short-form formats:	:stat:meas:ptr?
	:stat:ques:ptr?
	:stat:oper:ptr?
	:stat:oper:trig:ptr?
	:stat:oper:arm:ptr?
	:stat:oper:arm:seq:ptr?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 516, the binary equivalent is 0000001000000100. For this binary value, bits B9 and B2 are set.

Description

These commands are used to program the positive transition (PTR) registers. A positive transition is defined as a 0 to 1 state change in the condition register. Thus, when an event is programmed for a positive transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 0 to 1. For example, if bit B9 of the Positive Transition Register of the Measurement Transition Filter is set, then the buffer full event is programmed for a positive transition. The BFL bit (B9) in the Measurement Event Register will set when the trace buffer becomes full. For details on register structure, see paragraph 4.6.

The PTR registers are shown in Figures 4-34A through 4-39A. Included is the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program RAV (B5) and BFL (B9) measurement events for positive transitions, send the following command:

:stat:meas:ptr 544

where;	BFL (bit B9 = Decimal	512
	RAV (bit B5) = Decimal	32
	<NRf> =	544

Effects of positive transitions on the Measurement Event Register:

Measurement event	Positive transition effect on Measurement Event Register
Reading overflow	Sets B0 when reading exceeds range limits.
Low limit 1	Sets B1 when reading is less than the low limit 1 setting.
High limit 1	Sets B2 when reading is greater than the low limit 1 setting.
Low limit 2	Sets B3 when reading is less than the low limit 2 setting.
High limit 2	Sets B4 when reading is greater than the high limit 2 setting.
Reading available	Sets B5 after a reading is taken and processed.
Buffer available	Sets B7 when the trace buffer has at least two readings.
Buffer half full	Sets B8 when the trace buffer becomes half full.
Buffer full	Sets B9 when the trace buffer becomes full.
Buffer pretriggered	Sets B11 when the trace buffer pretrigger event occurs.

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	BPT	—	BFL	BHF	BAV	—	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	——	2048 (2^{11})	—	512 (2^{9})	256 (2^{8})	128 (2^{7})	—	32 (2^{5})	16 (2^{4})	8 (2^{3})	4 (2^{2})	2 (2^{1})	1 (2^{0})
Value	——	0/1	—	0/1	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	BPT	—	BFL	BHF	BAV	—	RAV	HL2	LL2	HL1	LL1	ROF
Decimal Weighting	——	2048 (2^{11})	—	512 (2^{9})	256 (2^{8})	128 (2^{7})	—	32 (2^{5})	16 (2^{4})	8 (2^{3})	4 (2^{2})	2 (2^{1})	1 (2^{0})
Value	——	0/1	—	0/1	0/1	0/1	—	0/1	0/1	0/1	0/1	0/1	0/1

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 4-34
Measurement Transition Filter

Effects of positive transitions on the Questionable Event Register:

Questionable event	Positive transition effect on Questionable Event Register
Temperature summary	Sets B4 when an invalid reference junction measurement has occurred.
Calibration summary	Sets B8 when an invalid calibration constant is detected on power-up.
Command warning	Sets B14 when a Signal Oriented Measurement Command parameter is ignored.

Bit Position	B15	B14	B13 - B9	B8	B7 - B5	B4	B3 - B0
Event	—	Warn	——	Cal	——	Temp	——
Decimal Weighting	—	16384 (2^{14})	——	256 (2^{8})	——	16 (2^{4})	——
Value	0	0/1	——	0/1	——	0/1	——

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15	B14	B13 - B9	B8	B7 - B5	B4	B3 - B0
Event	—	Warn	——	Cal	——	Temp	——
Decimal Weighting	—	16384 (2^{14})	——	256 (2^{8})	——	16 (2^{4})	——
Value	0	0/1	——	0/1	——	0/1	——

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 4-35
Questionable Transition Filter

Effects of positive transitions on the Operation Event Register:

Operation event	Positive transition effect on Operation Event Register
Calibrating	Sets B0 at the start of calibration.
Settling	Sets B1 at the start of the settling period.
trigger layer	Sets B5 when waiting in the trigger layer.
arm layer	Sets B6 when waiting in an arm layer.
Calculating	Sets B9 at the start of a math calculation.
Idle	Sets B10 when entering the idle state.

Bit Position	B15 - B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	Calc	—	—	Arm	Trig	—	—	—	Set	Cal
Decimal Weighting	——	1024 (2^{10})	512 (2^9)	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	1 (2^0)
Value	——	0/1	0/1	—	—	0/1	0/1	—	—	—	0/1	0/1

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	Calc	—	—	Arm	Trig	—	—	—	Set	Cal
Decimal Weighting	——	1024 (2^{10})	512 (2^9)	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	1 (2^0)
Value	——	0/1	0/1	—	—	0/1	0/1	—	—	—	0/1	0/1

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 4-36
Operation Transition Filter

Effects of positive transitions on the Trigger Event Register:

Trigger event	Positive transition effect on Trigger Event Register
Sequence 1	Sets B1 when waiting in trigger layer.

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 4-37
Trigger Transition Filter

Effects of positive transitions on the Arm Event Register:

Arm event	Positive transition effect on Arm Event Register
Sequence 1	Sets B1 when in an arm layer.

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (21)	—
Value	——	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 4-38
Arm Transition Filter

Effects of positive transitions on the Sequence Event Register:

Sequence event	Positive transition effect on Sequence Event Register
Layer 1	Sets B1 when in arm layer 1.
Layer 2	Sets B2 when in arm layer 2.

Bit Position	B15 - B3	B2	B1	B0
Event	——	Lay2	Lay1	—
Decimal Weighting	——	4 (2^2)	2 (2^1)	—
Value	——	0/1	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	B15 - B3	B2	B1	B0
Event	——	Lay2	Lay1	—
Decimal Weighting	——	4 (2^2)	2 (2^1)	—
Value	——	0/1	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 4-39
Sequence Transition Filter

Programming example

```
10  OUTPUT 716; ":stat:oper:ptr  1026; ptr?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets Bits B1 and B10 of the PTR Operation Transition Filter, and then queries the register.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set (1026).

4.21.4 :NTRansition <NRf>

:STATus:MEASurement:NTRansition <NRf> Program Measurement Transition Filter (NTR).
:STATus:QUEStionable:NTRansition <NRf> Program Questionable Transition Filter (NTR).
:STATus:OPERation:NTRansition <NRf> Program Operation Transition Filter (NTR).
:STATus:OPERation:TRIGger:NTRansition <NRf> Program Trigger Transition Filter (NTR).
:STATus:OPERation:ARM:NTRansition <NRf> Program Arm Transition Filter (NTR).
:STATus:OPERation:ARM:SEQuence:NTRansition <NRf> Program Sequence Transition Filter (NTR).

Parameters

<NRf>	= 0	Clear NTR register
	= 1	Set bit B0 of NTR register
	= 2	Set bit B1 of NTR register
	= 4	Set bit B2 of NTR register
	= 8	Set bit B3 of NTR register
	= 16	Set bit B4 of NTR register
	= 32	Set bit B5 of NTR register
	= 64	Set bit B6 of NTR register
	= 128	Set bit B7 of NTR register
	= 256	Set bit B8 of NTR register
	= 512	Set bit B9 of NTR register
	= 1024	Set bit B10 of NTR register
	= 2048	Set bit B11 of NTR register
	= 16384	Set bit B14 of NTR register

Formats

:stat:meas:ntr <NRf>
:stat:ques:ntr <NRf>
:stat:oper:ntr <NRf>
:stat:oper:trig:ntr <NRf>
:stat:oper:arm:ntr <NRf>
:stat:oper:arm:seq:ntr <NRf>

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query

:NTRansition?	Query NTR register
Short-form formats:	:stat:meas:ntr?
	:stat:ques:ntr?
	:stat:oper:ntr?
	:stat:oper:trig:ntr?
	:stat:oper:arm:ntr?
	:stat:oper:arm:seq:ntr?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 516, the binary equivalent is 0000001000000100. For this binary value, bits B9 and B2 are set.

Description These commands are used to program the negative transition (NTR) registers. A negative transition is defined as a 1 to 0 state change in the condition register. Thus, when an event is programmed for a negative transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 1 to 0. For example, if bit B9 of the Negative Transition Register of of the Measurement Transition Filter is set, then the buffer full event is programmed for a negative transition. The BFL bit (B9) in the Measurement Event Register will set when the trace buffer is no longer full. For details on register structure, see paragraph 4.6.

The NTR registers are shown in Figures 4-34B through 4-39B. Included is the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program RAV (B5) and BFL (B9) measurement events for negative transitions, send the following command:

:stat:meas:ntr 544

where;	BFL (bit B9) = Decimal	512
	RAV (bit B5) = Decimal	32
	<NRf> =	544

Effects of negative transitions on the Measurement Event Register:

Measurement event	Negative transition effect on Measurement Event Register
Reading overflow	Sets B0 when a reading has gone from overflow to normal.
Low limit 1	Sets B1 when the reading is no longer less than the low limit 1 setting.
High limit 1	Sets B2 when the reading is no longer greater than the low limit 1 setting.
Low limit 2	Sets B3 when the reading is no longer less than the low limit 2 setting.
High limit 2	Sets B4 when the reading is no longer greater than the high limit 2 setting.
Reading available	Sets B5 when the next reading is being taken.
Buffer available	Sets B7 when the trace buffer has become empty.
Buffer half full	Sets B8 when the trace buffer is no longer half full.
Buffer full	Sets B9 when the trace buffer is no longer full.
Buffer pretriggered	Sets when the trace buffer pretrigger operations are completed.

Effects of negative transitions on the Questionable Event Register:

Questionable event	Negative transition effect on Questionable Event Register
Temperature summary	Sets B4 when a valid reference junction measurement follows an invalid reference junction measurement.
Calibration summary	Sets B8 when an invalid calibration constant clears after a successful calibration.
Command warning	Sets B14 when a Signal Oriented Measurement Command parameter executes correctly after a previous Signal Oriented Measurement Command parameter has been ignored.

Effects of negative transitions on the Operation Event Register:

Operation event	Negative transition effect on Operation Event Register
Calibrating	Sets B0 at the end of calibration.
Settling Sets	B1 at the end of the settling period.
Trigger layer	Sets B5 when leaving the trigger layer.
Arm layer	Sets B6 when leaving an arm layer.
Calculating	Sets B9 at the end of a math calculation.
Idle	Sets B10 when leaving the idle state.

Effects of negative transitions on the Trigger Event Register:

Trigger event	Negative transition effect on Trigger Event Register
Sequence 1	Sets B1 when leaving the trigger layer.

Effects of negative transitions on the Arm Event Register:

Arm event	Negative transition effect on Arm Event Register
Sequence 1	Sets B1 when leaving an arm layer.

Effects of negative transitions on the Sequence Event Register:

Sequence event	Negative transition effect on Sequence Event Register
Layer 1	Sets B1 when leaving arm layer 1.
Layer 2	Sets B2 when leaving arm layer 2.

Programming example

```
10  OUTPUT 716; ":stat:oper:ntr  1026; ntr?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets Bits B1 and B10 of the NTR Operation Transition Filter, and then queries the register.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set (1026).

4.21.5 :CONDition?

:STATus:MEASurement:CONDition?	Read Measurement Condition Register
:STATus:QUEStionable:CONDition?	Read Questionable Condition Register
:STATus:OPERation:CONDition?	Read Operation Condition Register
:STATus:OPERation:TRIGger:CONDition?	Read Trigger Condition Register
:STATus:OPERation:ARM:CONDition?	Read Arm Condition Register
:STATus:OPERation:ARM:SEQuence:CONDition?	Read Sequence Condition Register

Formats

:stat:meas:cond?

:stat:ques:cond?

:stat:oper:cond?

:stat:oper:trig:cond?

:stat:oper:arm:cond?

:stat:oper:arm:seq:cond?

Description

These query commands are used to read the contents of the condition registers. Each set of event registers (except the Standard Event register set) has a condition register. A condition register is similar to its corresponding event register, except that it is a real-time register that constantly updates to reflect the current operating status of the instrument.

See [:EVENt] for register bit descriptions. Note from the status structure (paragraph 4.6) that the condition registers precede the transition filters. Thus, only the PTR descriptions apply to the condition registers.

After sending one of these commands and addressing the Model 2001 to talk, a decimal value is sent to the computer. The binary equivalent of this decimal value indicates which bits in the register are set.

For example, if sending :stat:meas:cond? returns a decimal value of 512 (binary 0000001000000000), bit B9 of the Measurement Condition Register is set indicating that the trace buffer is full.

Programming example

```
10  OUTPUT 716; ":stat:oper:cond?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Queries the Operation Condition Register.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set.

4.21.6 :PRESET

:STATUS:PRESET — Return 2001 to default conditions

Format :stat:pres

Description When this command is sent, the SCPI event registers are affected as follows:

1. All bits of the positive transition filter registers are set to one (1).
2. All bits of the negative transition filter registers are cleared to zero (0).
3. All bits of the following registers are cleared to zero (0):
   A. Operation Event Status Enable Register.
   B. Questionable Event Status Enable Register.
   C. Measurement Event Status Enable Register.
4. All bits of the following registers are set to one (1):
   A. Trigger Event Status Enable Register.
   B. Arm Event Status Enable Register.
   C. Sequence Event Status Enable Register.

Note: Registers not included in the above list are not affected by this command.

Programming example The following programming example demonstrates how to use the :PRESet command of the STATus subsystem:

```
OUTPUT 716; :stat:pres
```

4.21.7 :QUEue commands

[:NEXT]?

:STATus:QUEue[:NEXT]? — Read Error Queue

Format :stat:que?

Defaults

Power-Up	Clears Error Queue
*CLS	Clears Error Queue
:STATus:PRESet	No effect

Description As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages.

The Error Queue is a first-in, first-out (FIFO) register. Every time you read the queue, the "oldest" message is read and that message is then removed from the queue. The queue will hold up to 10 messages. If the queue becomes full, the message "350, 'Queue Overflow'" will occupy the last memory location in the register. On power-up, the Error Queue is empty. When the Error Queue is empty, the message "0, 'No error'" is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. The messages are listed in Table 3-4.

After this command is sent and the Model 2001 is addressed to talk, the "oldest" message in the queue is sent to the computer.

Note: The :STATus:QUEue[:NEXT]? query command performs the same function as the :SYSTem:ERRor? query command (see System subsystem).

Programming example

The following program will read the "oldest" message in the Error Queue:

```
5   DIM A$ [30]
10  OUTPUT 716; ":stat:que?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 5 Increase string size to accommodate the length of the messages.
Line 10 Requests the "oldest" message in the queue.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the message on the CRT.

ENABle <list>

:STATus:QUEue:ENABle <list> Enable messages for Error Queue

Parameter

<list> = (numlist)

where; numlist is a specified list of messages that you wish to enable for the Error Queue.

Format

:stat:que:enab (numlist)

Defaults

Power-up	Clears list
*CLS	No effect
:STATus:PRESet	No effect

Query

:ENABle?	Query list of enabled messages
Short-form format:	:stat:que:enab?
Response message:	numlist

Description

On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want enabled. Messages not specified will be disabled and prevented from entering the queue.

When this command is sent, all messages will first be disabled, then the messages specified in the list will be enabled. Thus, the returned list (:ENABle?) will contain all the enabled messages.

Messages are specified by numbers (see Table 3-4). The following examples show various forms for expressing a message numlist:

Numlist = -110	Single message.
= -110, -140, -222	Messages separated by commas.
= -110:-222	Range of messages (-100 through -222).
= -110:-222, -230	Range entry and single entry separated by a comma.

Note: To disable all messages from entering the Error Queue, send the following command:

:stat:que:enab ()

Programming example

```
10  OUTPUT 716; ":stat:que:enab  (0:-999); enab?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables all SCPI defined messages.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the messages (0:-999).

DISable <list>

:STATus:QUEue:DISable <list> Disable messages for Error Queue

Parameter <list> = (numlist)

where; numlist is a specified list of messages that you wish to disable for the Error Queue.

Format :stat:que:dis (numlist)

Defaults

Power-up	Clears list
*CLS	No effect
:STATus:PRESet	No effect

Query

:DISable?	Query list of disabled messages
Short-form format:	:stat:que:dis?
Response message:	numlist

Description On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want disabled. Disabled messages are prevented from going into the Error Queue.

Messages are specified by numbers (see Table 3-4). The following examples show various forms for expressing a message numlist:

Numlist = -110	Single message.
= -110, -140, -222	Messages separated by commas.
= -110:-222	Range of messages (-100 through -222).
= -110:-222, -230	Range entry and single entry separated by a comma.

Programming example

```
10  OUTPUT 716; ":stat:que:dis  (-140:-150); dis?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Disables messages -140 through -150.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the disabled messages (-140:-150).

:CLEar

:STATus:QUEue:CLEar — Clear Error Queue

Format :stat:que:cle

Description This action command is used to clear the Error Queue of messages.

Programming example

```
OUTPUT 716; ":stat:que:cle"          ! Clear Error Queue.
```

4.22 :SYSTem subsystem

The SYSTem subsystem contains miscellaneous commands that are summarized in Table 4-29.

Table 4-29
SYSTem command summary

Command	Description	Reference
:SYSTem		
:PRESet	Return to :SYST:PRES defaults.	4.22.1
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.	4.22.2
:POSetup?	Query power-on setup.	
:FRSWitch?	Query INPUTS switch (0 = rear, 1 = front).	4.22.3
:VERSion?	Query rev level of SCPI standard.	4.22.4
:ERRor?	Query (read) Error Queue.	4.22.5
:AZERo	Path to set up auto-zero.	4.22.6
:TYPE <name>	Select auto-zero mode: NORMal, SYNChronous.	
:TYPE?	Query auto-zero mode (0 or 1).	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) auto-zero.	
:STATe?	Query auto-zero (0 or 1).	
:AMEThod <name>	Select reading acquisition method: BURSt, NORMal, ASTReam, SSTReam	4.22.7
:AMEThod?	Query acquisition method.	
:LSYNc	Path to control line synchronization of measurements.	4.22.8
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) line sync.	
:STATe?	Query line sync (0 or 1).	
:KEY <NRf>	Simulate key-press (1 to 31; see Figure 4-40).	4.22.9
:KEY?	Query the last "pressed" key.	
:CLEar	Clears messages from the Error Queue.	4.22.10
:FETCh	Path to set fetch format:	4.22.11
:FORMat <name>	Select format for :FETCh? command; SCPI or FRESh.	

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.22.1 :PRESet

:SYSTem:PRESet — Return to :SYSTem:PRESet defaults

Format :syst:pres

Description This command returns the instrument to states optimized for front panel operation. Appendix B lists the default conditions for this command.

Programming example

```
OUTPUT 716; ":syst:pres"        ! Return 2001 to default states
```

4.22.2 :POSetup <name>

:SYSTem:POSetup <name> Program power-on defaults

Parameters

<name> = RST Select *RST defaults on power up
= PRESet Select :SYSTem:PRESet defaults on power up
= SAVX Select saved defaults on power up
where; X = 0 to 9

Format

:syst:pos <name>

Query

:POSetup? Query power-on setup
Short-form format: :syst:pos?
Response message: RST, PRES, SAV0-SAV9

Description

This command is used to program the power-on defaults. With RST selected, the instrument will power up to the *RST default conditions. With PRES selected, the instrument will power up to the :SYStem:PRESet default conditions. Appendix B defines the default conditions for these commands.

With one of the SAV parameters selected, the instrument will power-on to the setup that is saved in the specified memory location using the *SAV command. Valid SAV parameters depend on which memory option is installed in the Model 2001 and are summarized as follows:

Memory option	Valid SAV parameters
STD	SAV0
MEM1	SAV0 through SAV4
MEM2	SAV0 through SAV9

Programming example

```
10  OUTPUT 716; ":syst:pos  pres; pos?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects :SYSTem:PRESet power-on defaults, and the second queries the power-on setup.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the power-on setup (PRES).

4.22.3 :FRSWitch?

:SYSTem:FRSWitch? Read INPUTS switch

Format

:syst:frsw?

Description

This query command is used to read the position of the FRONT/REAR INPUTS switch. After sending this command and addressing the Model 2001 to talk, the code that indicates switch position will be sent to the computer. Switch position code is defined as follows:

1 = Front panel inputs selected
0 = Rear panel inputs selected

Programming example

```
10  OUTPUT 716; ":syst:frsw?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Reads the inputs switch position.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the position of the switch (0 or 1).

4.22.4 :VERSion?

:SYSTem:VERSion? Read SCPI version

Format

:syst:vers?

Description

This query command is used to read the version of the SCPI standard being used by the Model 2001. After sending this command and addressing the Model 2001 to talk, the version code will be sent to the computer. Example code:

1991.0

The above response message indicates the version of the SCPI standard.

Programming example

```
10  OUTPUT 716; ":syst:vers?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Reads the version of the SCPI standard.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the SCPI standard version.

4.22.5 :ERRor?

:SYSTem:ERRor? Read Error Queue

Format

:syst:err?

Defaults

Power-up	Clears Error Queue
*RST	No effect
*CLS	Clears Error Queue
DCL, SDC	No effect
:SYSTem:PRESet	No effect
:STATus:PRESet	No effect

Description

As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages. The Error Queue is a first-in, first-out (FIFO) register that can hold up to 10 messages. Every time you read the queue, the "oldest" message is read and that message is then removed from the queue.

If the queue becomes full, the message "350, 'Queue Overflow'" will occupy the last memory location in the register. On power-up, the queue is empty. When the Error Queue is empty, the message "0, 'No error'" is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. Table 3-4 lists the messages.

After this command is sent and the Model 2001 is addressed to talk, the "oldest" message in the queue is sent to the computer.

NOTE: The :SYSTem:ERRor? query command performs the same function as the :STATus:QUEue? query command (see STATus subsystem).

Programming example

```
10  DIM A$ [30]
20  OUTPUT 716; ":syst:err?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Increases string size to accommodate message.
Line 20 Reads the Error Queue.
Line 30 Addresses the Model 2001 to talk.
Line 40 Displays the message from the Error Queue.

4.22.6 :AZERo commands

:TYPE <name>

:SYSTem:AZERo:TYPE <name> Specify auto-zero type

Parameters

<name> = NORMal Auto-zero every 200msec
= SYNChronous Auto-zero for every reading

Format

:syst:azer:type <name>

Defaults

Power-up	Saved power-on setup
*RST	NORMal
:SYSTem:PRESet	NORMal

Query

:TYPE?	Query auto-zero type
Short-form format:	:syst:azer:type?
Response message:	NORM or SYNC

Description

The :AZERo commands are used to control the auto-zero phase of each measurement. During a normal reading conversion, the input signal is compared against a measured reference signal and a measured zero signal to ensure an accurate measurement. When auto-zero is disabled, the zero signal measurement is not performed, allowing the reading rate to be increased. However, accuracy is compromised. The longer auto-zero is disabled, the more inaccurate the readings become.

The :TYPE command is used to select auto-zero type. When SYNChronous auto-zero is enabled (see :STATe), the zero signal measurement will occur with every reading conversion. When NORMal auto-zero is enabled, the zero signal measurement will occur every 200msec.

Normal auto-zero is a compromise between synchronous auto-zero and disabling auto-zero. It will give you better speed than synchronous auto-zero and update zero at a regular interval.

Programming example

```
10  OUTPUT 716; ":syst:azer:type  sync; type?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects synchronous auto-zero, and the second queries the auto-zero type.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays auto-zero type (SYNC).

:STATe <b>

:SYSTem:AZERo:STATe <b> Control auto-zero

Parameters

<b>	= 1 or ON	Enable auto-zero
	= 0 or OFF	Disable auto-zero

Format

:syst:azer:stat <b>

Defaults

Power-up	Saved power-on setup
*RST	ON
:SYSTem:PRESet	ON

Query

:STATe?	Query state of auto-zero
Short-form format:	:syst:azer:stat?
Response message:	1 (on) or 0 (off)

Description

This command is used to disable or enable auto-zero.

Important Note: Before you can enable or disable auto-zero, the Model 2001 must first be in the idle state. The Model 2001 can be placed in the idle state by first disabling continuous initiation (:INITiate:CONTinuous OFF), and then sending the :ABORt command. After sending the :STATe command, readings can be re-started by sending :INITiate:CONTinuous ON or :INITiate.

Programming example

```
10  OUTPUT 716; ":init:cont  off; :abor"
20  OUTPUT 716; ":syst:azer:stat off; stat?"
30  ENTER 716; A$
40  PRINT A$
50  OUTPUT 716; ":init:cont:on"
60  END
```

Line 10 Two commands in this program message; the first disables continuous initiation, and the second places the Model 2001 in the idle state.
Line 20 Two commands in this program message; the first disables auto-zero, and the second queries the state of auto-zero.
Line 30 Addresses the Model 2001 to talk.
Line 40 Displays the state of auto-zero (0; off).
Line 50 Re-starts the measurement process.

NOTE: When finished, be sure to re-enable auto-zero.

4.22.7 :AMEThod <name>

:SYSTem:AMEThod <name> Specify acquisition method

Parameters

<name>	= NORMal	Normal acquisition method for buffer
	= BURSt	Burst acquisition method for buffer
	= ASTReam	ASCII stream mode
	= SSTReam	Single integer stream mode

Format

:syst:amet <name>

Defaults

Power-up	NORMal
*RST	NORMal
:SYSTem:PRESet	NORMal

Query

:AMEThod?	Query acquisition method
Short-form format:	:syst:amet?
Response message:	NORM, BURS, ASTR or SSTR

Description

BURST and NORMal

These parameters are used to specify the acquisition method for storing readings in the buffer. With the NORMAL method, readings will be stored at a rate that is determined by how the instrument is configured (i.e. integration period, resolution and filter).

When BURSt acquisition is selected, the Model 2001 is automatically configured for optimum speed (The instrument's previous configuration is restored when normal acquisition is again selected). The burst mode configures the buffer for compact grouping (see :TRACe:EGRoup). Thus, the time-stamp is not available for burst acquisition.

Burst acquisition can be performed for normal DCV, RMS and average ACV, normal DCI, RMS and average ACI, and normal Ω2 measurements.

Before selecting the burst acquisition mode, configure the Model 2001 for the desired measurements (such as a valid function, a manual measurement range, and a math calculation (:CALCulate1) if desired). Also, configure the buffer for the number of readings to be stored (see Trace subsystem).

After burst acquisition is selected, the instrument will go into the idle state (ARM indicator off). After taking the instrument out of idle (:INITiate or :INITiate:CONTinuous ON), the programmed scan event (:see :ARM:LAYer2 SOURce) will start the storage process.

When storage starts, the ARM indicator will turn on to denote that raw input readings are being stored in the buffer. After the storage process is finished, the * indicator will turn on to denote that post processing (i.e. math calculations) is being performed on the readings. When post processing is finished, the * indicator will turn off and the instrument will return to the idle state. The Trace subsystem is used to read the buffer.

Sending a bus command to the Model 2001 while raw reading are being acquired will abort the acquisition and post process the readings already stored in the buffer.

NOTE: See Section 3 of this manual for complete information on burst mode.

ASTReam and SSTReam

These two "stream" parameters are used to send "fresh" A/D readings over the IEEE-488 bus at maximum speed. The ASTReam parameter is used to send readings in the ASCII format, and the SSTReam parameter is used to send readings in the Single Integer (counts) format. The stream modes can be used for the following functions: DCV, ACV (average and RMS), DCI, ACI (average and RMS) and Ω2. TEMP, FREQ, Ω4, in-circuit current, and peak measurements cannot be used for stream mode.

With ASTReam, up to 1000 readings per second can be sent over the bus, and with SSTReam, up to 2000 readings per second can be sent. Once the Model 2001 is placed in a stream mode, one A/D reading will be sent over the bus every time the instrument is addressed to talk.

ASCII stream mode:

With ASTReam, only the reading is sent. All other data elements (units, reading number, time stamp, etc.) are not included. For example, a 150Ω reading on the 200Ω range will be sent as follows:

+150.00E+00

A line feed (LF) with EOI is used as a terminator for each reading. An overflowed reading is returned as a +/-30,000 count reading. For example, a 10kΩ resistor being measured on the 2kΩ range will return the following overranged reading:

+3.0000E+03 (Overranged ASTReam reading)

Single integer stream mode:

The SSTReam mode sends single precision integer readings. Each reading is 2-bytes in size and is not terminated by a line feed (LF). EOI is asserted with the second byte of each reading.

With SSTReam, only the number of A/D counts are sent. For example, a 1.5V reading on the 2V range will be sent as follows:

15000

The same reading (1.5V) on the 20V range is sent as follows:

1500

An overrange reading is expressed as +/-30,000 counts. For example, if a 50kΩ resistor is measured on the 20kΩ range, the overranged reading will be expressed as follows:

30000 (Overranged SSTReam reading)

Operating considerations:

Before going into a stream mode, make sure the instrument is on the desired function and range. Once in a stream mode, all front panel controls are disabled, and all SCPI and Common commands are ignored.

Before going into the SSTReam mode, make sure the data format byte order is correct for your computer. IBM and IBM compatibles require the swapped byte order and HP requires normal byte order (see :FORMat:BORDer).

Important Note: Before going into a stream mode, the instrument must be in continuous initiation. If continuous initiation is disabled (or you are not sure), send the following command to enable it:

:INITiate:CONTinuous ON

When the :AMEThod command is sent with one of the stream parameters, the instrument will go into the stream mode and lock out all front panel controls, and ignore all SCPI and Common commands. When a stream mode is entered, you must wait before addressing the Model 2001 to talk. The minimum delay period is dependent on function and range (see Table 4-30). In a stream mode, the instrument configures itself as follows:

Auto zero disabled (:SYSTem:AZERo:STATe OFF)
CALC 1 disabled (:CALCulate[1]:STATe OFF)
Line synchronization disabled (:SYSTem:LSYNc:STATe OFF)

For each valid function:

<function> = :VOLTage:AC
= :VOLTage:DC
= :CURRent:AC
= :CURRent:DC
= :RESistance

Auto range disabled (<function>:RANGe:AUTO OFF)
NPLC = 0.01 (<function>:NPLCycles 0.01)
Auto NPLC disabled (<function>:NPLCycles:AUTO OFF)
Resolution = 4½ digits (<function>:DIGits 4)
Auto resolution disabled (<function>:DIGits:AUTO OFF)
Filter disabled (<function>:AVERage:STATe OFF)
Auto filter disabled (<function>:AVERage:AUTO OFF)
Reference disabled (<function>:REFerence:STATe OFF)

The stream mode is cancelled when a device clear (DCL or SDC) is sent to the Model 2001. Keep in mind that the instrument will remain at the settings that it assumed for the stream mode. After cancelling the stream mode, again wait before sending any more commands. (See Table 4-30.)

The delay times in Table 4-30 only account for processing the stream command and the device clear command. Commands that precede the stream command must be allowed to finish executing before the stream command is sent. The *OPC? command is recommended for this purpose. When *OPC? is sent, subsequent commands will not execute until the operations of all previous commands are completed. The use of *OPC? is demonstrated in Program Example #2.

Triggering — In stream, the trigger model functions normally except that the Manual and Hold control sources cannot be used. The Group Execute Trigger (GET) is functional when the Bus control source is selected. For optimum speed, set up the measure layer for Immediate control source, infinite count and zero delay.

Reading Rates — The maximum possible reading rate for the SSTReam mode is 2000 per second and is only achievable for controllers that can pull each reading out of the Model 2001 in less than 100µsec. The maximum possible reading rate for the ASTReam mode is 1000 per second. Maximum reading rates require that the measure layer of the trigger model be configured for the Immediate control source, infinite count and zero delay. When externally triggered (EXT, TLINK, TIMER or GET), the maximum reading rate for either stream mode is 680 per second.

Table 4-30
Minimum delay times for stream mode

Function	Range	Delay (msec)
DCV	200mV	150
	2V	160
	20V	150
	200V	220
	1000V	210
ACV (RMS and average)	200mV	270
	2V	260
	20V	210
	200V	200
	750V	210
DCI	200µA	130
	2mA	140
	20mA	170
	200mA	140
	2A	190
ACI (RMS and average)	200µA	230
	2mA	180
	20mA	230
	200mA	220
	2A	160
Ω2	20Ω	190
	200Ω	180
	2kΩ	140
	20kΩ	170
	200kΩ	270
	2MΩ	880
	20MΩ	1840
	200MΩ	1920
	1GΩ	1920

Programming example

Burst acquisition

```
10  OUTPUT 716; ":syst:pres"
20  OUTPUT 716; ":syst:amet  burs"
30  OUTPUT 716; ":init"
40  END
```

Line 10 Returns Model 2001 to defaults.
Line 20 Selects burst acquisition mode.
Line 30 Starts the acquisition process.

Programming example ASTReam mode

```
10  REMOTE 716
20  OUTPUT 716; ":syst:pres"
30  OUTPUT 716; ":sens:func  'volt:dc' "
40  OUTPUT 716; ":sens:volt:dc:rang  2.0; *opc?"
50  ENTER 716; opc$
60  OUTPUT 716; ":syst:amet  astr"
70  WAIT (0.160)
80  FOR I=1 TO 200
90  ENTER 716; rdg$
100 NEXT I
110 CLEAR 716
120 WAIT (0.160)
130 END
```

Line 20 Select :SYST:PRES defaults.
Line 30 Select DC volts.
Line 40 Select 2V range; query operation complete.
Line 50 Wait for operation complete.
Line 60 Go into the ASTReam (ASCII) mode.
Line 70 Wait for 0.160sec.
Line 80 Set up loop to repeat 200 times.
Line 90 Address Model 2001 to talk.
Line 100 Repeat loop until 200 readings are sent.
Line 110 Send device clear to cancel stream mode.
Line 120 Wait for 0.160sec.

4.22.8 :LSYNc:STATe <b>

:SYSTem:LSYNc:STATe <b> Control line synchronization

Parameters

<b>	= 0 or OFF	Disable line synchronization
	= 1 or ON	Enable line synchronization

Format :syst:lsyn:stat <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query

:STATe?	Query state of line synchronization
Short-form format:	:syst:lsyn:stat?
Response message:	0 (off) or 1 (on)

Description This command is used to enable or disable line synchronization. When enabled, the integration period will not start until the beginning of the next power line cycle. For example, if a reading is triggered at the positive peak of a power line cycle, the integration period will not start until that power line cycle is completed. The integration period starts when the positive-going sine wave crosses zero volts.

With line synchronization disabled, the integration period will simply start when the reading is triggered. See paragraph 3-12 for details.

Programming example

```
10  OUTPUT 716; ":syst:lsyn:stat  on; stat?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first enables line sync, and the second queries the state of line sync.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of line sync (1; on).

4.22.9 :KEY <NRf>

:SYSTem:KEY <NRf> Simulate key-press

Parameters

<NRf>	= 1	Up Arrow	<NRf> = 16	NEXT
	= 2	TEMP	= 17	Down Arrow
	= 3	Left Arrow	= 18	ENTER
	= 4	MENU	= 19	Ω4
	= 5	ACI	= 20	FILTER
	= 6	STORE	= 21	SCAN
	= 7	LOCAL	= 22	ACV
	= 8	PREV	= 23	REL
	= 9	AUTO	= 26	FREQ
	= 10	Right Arrow	= 27	MAT
	= 11	EXIT	= 28	CONFIG
	= 12	Ω2	= 29	DCI
	= 13	RECALL	= 30	TRIG
	= 14	CHAN	= 31	INFO
	= 15	DCV		

Format :syst:key <NRf>

Query

:KEY?	Query last "pressed" key.
Short-form format:	:syst:key?
Response message:	1 to 31

Description This command is used to simulate front panel key presses. For example, to select DCV you can send the following command to simulate pressing the DCV key:

```
:syst:key 15
```

The parameter listing provides the key-press code in numeric order. Figure 4-40 also provides the key-press code.

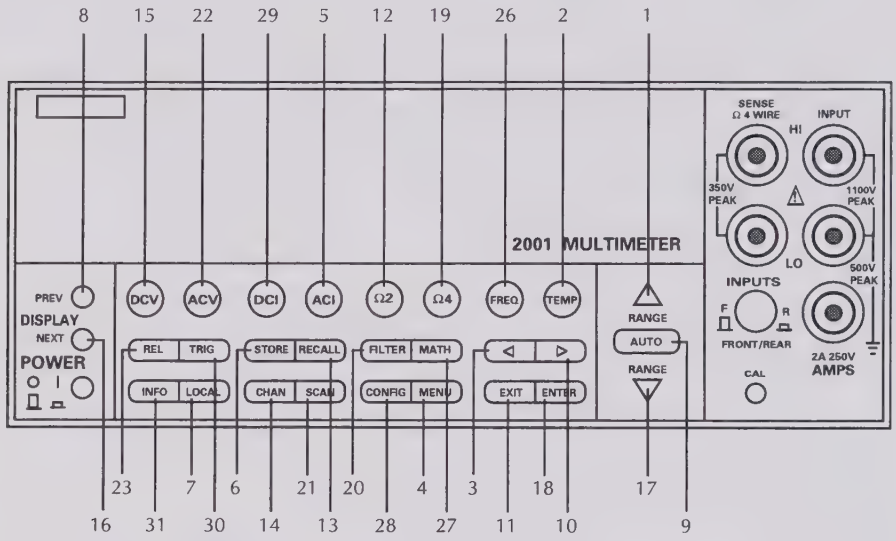


Figure 4-40
Key-press codes

The :KEY command allows you to select the NEXT displays over the bus. Sending :SYSTem:KEY 16 over the bus is same as a single press of the NEXT key. Sending :SYSTem:KEY 8 is the same as a single press of the PREV key. The NEXT display that is selected depends on which function is currently selected and how many times the NEXT key is "pressed" using the :KEY command. The instrument can always be returned to the normal display by "pressing" the PREV key a similar number of times, or by sending the :DISPlay:CNDisplay command.

For example, on the FREQ function, you can display the trigger level by "pressing" the NEXT key twice as follows:

:syst:key 16; key 16

To return to the normal display, "press" the PREV key twice as follows:

:syst:key 8; key 8

The order of NEXT displays for each measurement function is provided in the appendix for Menu Structures.

The queue for the :KEY? query command can only hold one key-press. When :KEY? is sent over the bus, and the Model 2001 is addressed to talk, the key-press code number for the last key pressed (either physically or with :KEY) will be sent to the computer.

Programming example

```
OUTPUT 716; ":syst:key 29"
OUTPUT 716; ":syst:key 16; key 16"
OUTPUT 716; ":syst:key 8; key 8"
```

First Program Message — Selects the DCI function.
Second Program Message — Selects the Zero Center Bar Graph.
Third Program Message — Returns the Model 2001 to the normal display.

4.22.10 :CLEar

:SYSTem:CLEar — Clear Error Queue

Format :syst:cle

Description This action command is used to clear the Error Queue of messages.

Programming example

```
OUTPUT 716; ":stat:cle"          ! Clear Error Queue.
```

4.22.11 :FETCh:FORMat <name>

:SYSTem::FETCh:FORMat <name> — Select fetch format

Parameters

<name>	= SCPI	Select the SCPI format for :FETCh?
	= FRESh	Select the FRESh format for :FETCh?

Format :syst:fetc:form <name>

Query

:FETCh:FORMat?	Query fetch format
Short-form format:	:syst:fetc:form?
Response message:	SCPI, FRES

Description This command is used to select the format for the :FETCh? signal oriented measurement command. With SCPI selected, :FETCh? will request the latest reading. With FRESh selected, :FETCh? will request a fresh reading. See :FETCh? for more information.

At power-on, the fetch format will be set to FRESh, and all elements will be included in the data string for each measurement conversion (see :FORMat:ELEMents).

Note that the fetch format is not affected by *RST or :SYSTem:PRESet. However, with the SCPI format selected, *RST will set the :FORMat:ELEMent command for READing only.

Also not that the fetch format is not remembered by the *SAV common command.

Programming example

```
10  OUTPUT 716; ":syst:fetc:form  scpi; form?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects the SCPI fetch format and queries the format.
Line 20 Addresses the 2001 to talk.
Line 30 Displays the fetch format (SCPI).

4.23 :TRACe subsystem

The commands in this subsystem are used to configure and control data storage into the buffer. The commands are summarized in Table 4-31.

Table 4-31
TRACe command summary

Command	Description	Reference
:TRACe|:DATA	Use :TRACe or :DATA as root command.	
:CLEar [BUFFER,]	Clear readings from buffer.	4.23.1
:FREE? [BUFFER,]	Query bytes available and bytes in use.	4.23.2
:EGRoup [BUFFER,] <name>	Select element group: FULL, COMPact.	4.23.3
:EGRoup? [BUFFER,]	Query element group.	
:POINts [BUFFER,] <n>	Specify size of buffer.	4.23.4
:AUTO [BUFFER,] <b>	Enable (1 or ON) or disable auto buffer sizing.	
:AUTO? [BUFFER,]	Query state of auto buffer sizing.	
:POINts? [BUFFER,]	Query buffer size.	
:FEED [BUFFER,] <name>	Select source of readings: SENSe[1], CALCulate[1], NONE.	4.23.5
:PRETrigger	Path to configure pre-trigger storage mode.	
:AMOunt	Path to specify number of pre-trigger readings.	
[:PERCent] [BUFFER,] <n>	Specify as a % (0 to 100) of buffer.	
[:PERCent]? [BUFFER,]	Query percentage.	
:READings [BUFFER,] <n>	Specify as a number.	
:READings? [BUFFER,]	Query number of readings.	
:SOURce [BUFFER,] <name>	Select pre-trigger source event:EXTernal, TLINk, BUS, MANual.	
:SOURce? [BUFFER,]	Query pre-trigger source event.	
:CONTrol [BUFFER,] <name>	Select buffer control mode:NEVer, NEXT, ALWays, PRETrigger.	
:CONTrol? [BUFFER,]	Query buffer control mode.	
:FEED? [BUFFER,]	Query source of readings for buffer.	
:DATA? [BUFFER,]	Read all readings in the buffer.	4.23.6

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

:TRACe | :DATA

The bar (|) indicates that :TRACe or :DATA can be used as the root command for this subsystem. From this point on, the documentation in this manual will use :TRACe. If you prefer to use :DATA, simply replace all the :TRACe command words with :DATA.

4.23.1 :CLEar [BUFFER,]

:TRACe:CLEar [BUFFER,] Clear buffer

Format :trac:cle

Description This action command is used to clear the buffer of readings. If you do not clear the buffer, a subsequent store will overwrite the old readings. If the subsequent store is aborted before the buffer becomes full, you could end up with some "old" readings still in the buffer.

Programming example

```
OUTPUT 716; ":trac:cle"          ! Clear buffer
```

4.23.2 :FREE? [BUFFER,]

:TRACe:FREE? [BUFFER,] Read status of memory

Format

```
:trac:free?
```

Description This command is used to read the status of storage memory. After sending this command and addressing the Model 2001 to talk, two values separated by commas will be sent to the computer. The first value will indicate how many bytes of memory are available, and the second value will indicate how many bytes are currently being used to store readings.

Programming example

```
10  OUTPUT 716; ":trac:free?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Request status of memory.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays status of memory.

4.23.3 :EGRoup [BUFFER,] <name>

:TRACe:EGRoup [BUFFER,] <name> Specify element group

Parameters

<name>	= FULL	Time stamp included with each stored reading
	= COMPact	Time stamp not included

Format

```
:trac:egr <name>
```

Defaults

Power-up	FULL
*RST	No effect
:SYSTem:PRESet	No effect

Query

:EGRoup? [BUFFER,]	Query element group
Short-form format:	:trac:egr?
Response message:	FULL or COMP

Description This command is used to select the element group that is sent with each reading. Common to both element groups are function, channel (if applicable) and buffer location. The FULL element group includes the time stamp. The first reading in the buffer has a time stamp of 0 seconds. The time stamp for all subsequent readings are then referenced to the first reading.

The COMpact element group excludes the time stamp. This allows the more readings to be stored in the buffer (see :POINts).

Programming example

```
10  OUTPUT 716; ":trac:egr  comp; egr?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects the compact element group, and the second queries the element group.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the element group (COMP).

4.23.4 :POINts [BUFFER,] <n>

:TRACe:POINts [BUFFER,] <n> Specify buffer size

Parameters

		No memory option	MEM 1	MEM 2	
<n>	=	2 to 250	2 to 1400	2 to 6000	(Full)
	=	2 to 850	2 to 7000	2 to 30000	(Compact)
	= MAXimum;	250	1400	6000	(Full)
		850	7000	30000	(Compact)
	= DEFault;	100 (all cases)			
	= MINimum;	2 (all cases)			

Format :trac:poin <n>

Defaults

Power-up	100 point buffer
*RST	No effect
:SYSTem:PRESet	No effect

Query

:POINts?

Short-form formats: :trac:poin?

Response message: 2 to 30000

Description This command is used to specify the size of the buffer. Notice that the valid parameter range depends on which memory option is installed, and which element group (full or compact) is being used (see :EGRoup).

Programming example

```
10  OUTPUT 716; ":trac:poin  50; poin?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first specifies a 50 point buffer size, and the second queries the buffer size.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the buffer size (50).

:AUTO [BUFFER,] <b>

:TRACe:POINts:AUTO [BUFFER,] <b> Control auto buffer sizing

Parameters

<b>	= 0 or OFF	Disable auto buffer sizing
	= 1 or ON	Enable auto buffer sizing

Format

:trac:poin:auto <b>

Defaults

Power-up	OFF
*RST	No effect
:SYSTem:PRESet	No effect

Query

:AUTO? [BUFFER,]
Short-form format: :trac:poin:auto?
Response message: 0 (off) or 1 (on)

Description

This command is used to enable or disable auto buffer sizing. When enabled, the buffer size will default to the measure count value in the Trigger Model (see :TRIGger:COUNt in Trigger subsystem). With auto enabled, changing the trigger model's measure count value will change the buffer size to that value.

Disabling auto buffer sizing will not affect the size of the buffer. It simply means that you must then use the :POINts command to change buffer size.

If you use the :POINts command to change the buffer size while auto is enabled, the buffer size will change to that value and auto buffer sizing will disable.

If you try to enable auto buffer sizing while the measure count is programmed for infinite, an error will occur and the command will be ignored. You cannot have an infinite buffer size.

Programming example

```
10  OUTPUT 716; ":trig:coun  200"
20  OUTPUT 716; ":trac:poin:auto on; auto?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Sets the measure count to 200.
Line 10 Two commands in this program message; the first enables auto buffer sizing, and the second queries the state of auto buffer sizing. Auto sets the buffer size to 200 points.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of auto buffer sizing (1; on).

4.23.5 :FEED [BUFFER,] <name>

:TRACe:FEED [BUFFER,] <name> Specify readings source

Parameters

<name>	= SENSe[1]	Put raw readings in buffer
	= CALCulate[1]	Put calculated readings in buffer
	= NONE	Put no readings in buffer

Format :trac:feed <name>

Defaults

Power-up	NONE
*RST	No effect
:SYSTem:PRESet	No effect

Query

:FEED? [BUFFER,]	Query buffer feed
Short-form format:	:trac:feed?
Response message:	SENS1, CALC1 or NONE

Description This command is used to select the source of readings to be placed in the buffer. With SENSe[1] selected, raw readings will be placed in the buffer when storage is performed. With CALCulate[1] selected, calculated math readings (mX+b or PERCENT or NONE) will be placed in the buffer.

With NONE selected, no readings will be placed in the buffer when storage is performed over the bus.

Programming example

```
10  OUTPUT 716; ":trac:feed  calc; feed?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects calculated math readings for the buffer, and the second queries the buffer feed.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the buffer feed (CALC1).

:[PERCent] [BUFFER,] <n>

:TRACe:FEED:PRETrigger:AMOunt:[PERCent] [BUFFER,] <n> Specify percent of pre-trigger readings

Parameters

<n>	= 0 to 100	% of buffer for pre-trigger readings
	= DEFault	50% of buffer for pre-trigger readings
	= MINimum	0% of buffer for pre-trigger readings
	= MAXimum	100% of buffer for pre-trigger readings

Format :trac:feed:pret:amo <n>

Defaults

Power-up	50%
*RST	No effect
:SYSTem:PRESet	No effect

Query

:[PERCent]? [BUFFER,]	
Short-form format:	:trac:feed:pret:amo?
Response message:	0 to 100 (%)

Description This command is used to specify how much of the defined buffer (:POINts) will be used to store pre-triggered readings. When a pre-trigger store is started (see :FEED:CONTrol), readings will continuously be stored in the buffer. When the pre-trigger event occurs (see :PRETrigger:SOURce), post-trigger readings will then fill the part of the buffer that is not reserved for pre-trigger readings.

For example, assume 25% of a 100 point buffer is reserved for pre-trigger readings. When the pre-trigger store is started, readings will continuously fill the buffer. When the pre-trigger event occurs, subsequent readings will then be stored starting at buffer location 26 and continuing until buffer location 100 is filled. Storage stops after buffer location 100 is filled. The result is 25 pre-trigger readings and 75 post-trigger readings.

Programming example

```
10  OUTPUT 716; ":trac:feed:pret:amo  25; amo?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first specifies that 25% of the buffer will be used for pre-trigger readings, and the second queries the percentage.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the percentage of the buffer to used for pre-trigger readings (25).

:READings [BUFFER,] <n>

:TRACe:FEED:PRETrigger:AMOunt:READings [BUFFER,] <n> Specify number of pre-trigger readings

Parameters

		No memory option	MEM 1	MEM 2	
<n>	=	2 to 250	2 to 1400	2 to 6000	(Full)
	=	2 to 850	2 to 7000	2 to 30000	(Compact)
	= MAXimum;	250	1400	6000	(Full)
		850	7000	30000	(Compact)
	= DEFault;	100 (all cases)			
	= MINimum;	2 (all cases)			

Format :trac:feed:pret:amo:read <n>

Defaults

Power-up	50
*RST	No effect
:SYSTem:PRESet	No effect

Query :READ? [BUFFER,]
Short-form formats: :trac:feed:pret:amo:read?
Response message: 0 to 30000

Description This command is used to specify how much of the defined buffer (:POINts) will be used to store pre-triggered readings. This command is essentially the same as the :PERCent command except the amount is expressed as an exact value instead of a percent.

Sending a value that exceeds the defined size of the buffer (see :POINts) will generate an error. The command will be ignored.

Programming example

```
10  OUTPUT 716; ":trac:poin  75"
20  OUTPUT 716; ":trac:feed:pret:amo:read  30; read?"
30  ENTER 716; A$
40  PRINT A$
50  END
```

Line 10 Sets buffer size to 75 points.

Line 20 Two commands in this program message; the first specifies 30 buffer points for pre-trigger readings, and the second queries the number of buffer points.

Line 30 Addresses the Model 2001 to talk.

Line 40 Displays the number of pre-trigger buffer points.

:SOURce [BUFFER,] <name>

:TRACe:FEED:PRETrigger:SOURce [BUFFER,] <name> Specify pre-trigger event

Parameters

<name>	= EXTernal	Use External Trigger as pre-trigger event
	= TLINk	Use Trigger Link as pre-trigger event
	= BUS	Use bus trigger as pre-trigger event
	= MANual	Use TRIG key as pre-trigger event

Format :trac:feed:pret:sour <name>

Defaults

Power-up	MANual
*RST	No effect
:SYSTem:PRESet	No effect

Query :SOURce? [BUFFER,] Query buffer source.
Short-form format: :trac:feed:pret:sour?
Response message: EXT, TLIN, BUS or MAN

Description

This command is used to specify the event for the pre-trigger storage mode. With the pre-trigger mode selected (:CONTrol, PRETrigger), readings will be continuously stored in the buffer while waiting for the pre-trigger source event.

With EXTernal source selected, an external trigger via the rear panel EXTERNAL TRIGGER Input will provide the pre-trigger event.

With TLINk selected, an input trigger via the Trigger Link will provide the pre-trigger event. The Trigger Link line used for the input trigger is programmed from the Trigger subsystem (see :TRIGger:TCONfigure command path).

With BUS selected, a GPIB bus trigger (GET or *TRG) will provide the pre-trigger event.

With MANual selected, pressing the front panel TRIG key will provide the pre-trigger event.

Once the pre-trigger event occurs, the buffer will take (points - pre-trigger amount) more readings then stop.

Programming example

```
10  OUTPUT 716; ":trac:feed:pret:sour  bus; sour?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects a bus trigger as the pre-trigger source event, and the second queries the source.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the source event (BUS).

:CONTrol [BUFFER,] <name>

:TRACe:FEED:CONTrol [BUFFER,] <name> Specify buffer control

Parameters

<name>	= NEVer	Disables buffer storage
	= NEXT	Fills buffer and stops
	= ALWays	Continuously stores readings in buffer
	= PRETrigger	Use pre-trigger mode to store readings

Format

:trac:feed:cont <name>

Defaults

Power-up	NEXT
*RST	No effect
:SYSTem:PRESet	No effect

Query

:CONTrol? [BUFFER,]	Query buffer control
Short-form format:	:trac:feed:cont?
Response message:	NEV, NEXT, ALW or PRET

Description

This command is used to select the buffer control. With NEVer selected, storage into the buffer is disabled. With any of the other selections, storage will be performed as long as buffer feed is not set for NONE (see :TRACe:FEED NONE). When NEXT is selected, the storage process will start, fill the buffer and then stop. The buffer size is specified by the :POINts command.

When ALWays is selected, the storage process will start and continue to store readings even after the buffer fills. After the buffer fills, readings will overwrite the previously stored readings.

When PRETrigger is selected, the buffer will store readings continuously (like ALWays) until the programmed pre-trigger event occurs. When the pre-trigger event occurs, the section of the buffer specified for post-trigger readings will fill with new readings. The storage process will stop when the post-trigger portion of the buffer becomes full with new readings (see :TRACe:FEED:PRETrigger).

Programming example

```
10  OUTPUT 716; ":trac:feed:cont  next; cont?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first will "fill and stop" storage, and the second queries the buffer control.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the buffer control (NEXT).

4.23.6 :DATA? [BUFFER,]

:TRACe:DATA? [BUFFER,] Send buffer readings

Format

```
:trac:data?
```

Description

When this command is sent and the Model 2001 is addressed to talk, all the readings stored in the buffer will be sent to the computer. The format that readings are sent over the bus is controlled by the :FORMat subsystem.

Programming example

```
10  OUTPUT 716; ":trac:data?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Reads the buffer contents.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the readings.

4.24 Trigger subsystem

The Trigger subsystem is made up of a series of commands and subsystems to configure the three layers of the Trigger Model (see Figure 4-13). These commands and subsystems are summarized in Table 4-32.

Table 4-32
Trigger command summary

Command	Description	Reference
:INITiate	Subsystem command path:	4.24.1
[:IMMediate]	Initiate one trigger cycle.	
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.	
:CONTinuous?	Query continuous initiation.	
:ABORt	Reset trigger system.	4.24.2
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:	
[:LAYer[1]]	Path to program arm layer 1:	
:IMMediate	Loop around control source.	4.24.3
:COUNt <n>	Program arm count (1 to 99999, or INF).	4.24.4
:COUNt?	Query arm count.	
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.	4.24.6
:SOURce?	Query control source.	
:SIGNal	Loop around control source.	4.24.8
:TCONfigure	Path to configure Triggers:	4.24.9
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:LAYer2	Path to program arm layer 2:	
:IMMediate	Loop around control source.	4.24.3
:COUNt <n>	Program scan count (1 to 99999 or INF).	4.24.4
:COUNt?	Query scan count.	
:DELay <n>	Program delay (0 to 999999.999 sec)	4.24.5
:DELay?	Query delay.	
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.	4.24.6
:SOURce?	Query control source.	
:TIMer <n>	Set timer interval (0 to 999999.999 sec).	4.24.7
:TIMer?	Query timer.	
:SIGNal	Loop around control source.	4.24.8
:TCONfigure	Path to configure Triggers:	4.24.9
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.	
:DIRection?	Query direction.	
:ASYNchornous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	

Table 4-32 (cont.)
Trigger command summary

Command	Description	Reference
:TRIGger[:SEQuence[1]]	Path to program trigger layer:	
:IMMediate	Loop around control source.	4.24.3
:COUNt <n>	Program measure count (1 to 99999, or INF).	4.24.4
:COUNt?	Query measure count.	
:DELay <n>	Program delay (0 to 999999.999 sec)	4.24.5
:DELay?	Query delay.	
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.	4.24.6
:SOURce?	Query control source.	
:TIMer <n>	Set timer interval (0 to 999999.999 sec).	4.24.7
:TIMer?	Request the programmed timer interval.	
:SIGnal	Loop around control source.	4.24.8
:TCONfigure	Path to configure Triggers:	4.24.9
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.	
:PROTocol?	Query protocol.	
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:SSYNchronous	Path to configure semi-synchronous Trigger Link:	
:LINE <NRf>	Select trigger line (1 to 6).	
:LINE?	Query trigger line.	

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

4.24.1 :INITiate commands

[:IMMediate]

:INITiate[:IMMediate] Take 2001 out of idle

Format :init

Description This command takes the Model 2001 out of the idle state. After all programmed operations are completed, the instrument will leave the trigger structure and return to the idle state (if continuous initiation is disabled; see next command).

Programming example

```
OUTPUT 716; ":init"          ! Takes 2001 out of the idle state.
```

:CONTinuous <b>

:INITiate:CONTinuous <b> Control continuous initiation

Parameters

<b>	= 0 or OFF	Disable continuous initiation
	= 1 or ON	Enable continuous initiation

Format

:init:cont <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

Query

:CONTinuous?	Query continuous initiation
Short-form format:	:init:cont?
Response message:	1 (on) or 0 (off)

Description

When continuous initiation is selected (ON), the instrument is taken out of the idle state. At the conclusion of all programmed operations, the instrument will return to arm layer 1.

Programming example

```
OUTPUT 716; ":init:cont  on"      ! Select continuous initiation
```

4.24.2 :ABORt

:ABORt Abort operation

Format

:abor

Description

When this action command is sent, the Model 2001 will abort its current operations and return to the top of the Trigger Model. If continuous initiation is disabled, the instrument will go into the idle state. If continuous initiation is enabled, operation will continue on into arm layer 1.

The abort command will reset the Source Bypasses of the Trigger Model. If scanning, the scan pointer will reset back to the first channel in the scan list.

Programming example

```
OUTPUT 716; ":abor"               ! Abort operation
```

4.24.3 :IMMediate

:ARM[:SEQuence[1]][:LAYer[1]]:IMMediate	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:IMMediate	Bypass scan control source and delay
:TRIGger:[:SEQuence[1]]:IMMediate	Bypass measure control source and delay

Formats

:arm:imm
:arm:lay2:imm
:trig:imm

Description

These action commands are used to bypass the specified control source of the Trigger Model. They are used when you do not wish to wait for the programmed event. Note from the Trigger Model (Figure 4-14) that :arm:lay2:imm and :trig:imm also bypass the Delay.

The instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and the command will be ignored. When the command is sent, the bypass will occur and operation will continue on.

Note that :IMMediate is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the specified control source.

Programming example

```
OUTPUT 716; ":arm:imm"          ! Bypass arm control source
```

4.24.4 :COUNt <n>

```
:ARM[:SEQuence[1]][:LAYer[1]]:COUNt  <n>    Set arm layer count
:ARM[:SEQuence[1]]:LAYer2:COUNt  <n>        Set scan layer count
:TRIGger[:SEQuence[1]]:COUNt  <n>           Set measure layer count
```

Parameters

<n>	= 1 to 99999	Specify count
	= INF	Sets count to infinite
	= DEFault	Sets count to 1
	= MINimum	Sets count to 1
	= MAXimum	Sets count to 99999

Formats

```
:arm:coun  <n>
:arm:lay2:coun  <n>
:trig:coun  <n>
```

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (all layers)

Query

:COUNt?	Queries programmed count
:COUNt? DEFault	Queries *RST default count
:COUNt? MINimum	Queries lowest allowable count
:COUNt? MAXimum	Queries largest allowable count
Short-form formats:	:arm:coun? :arm:lay2:coun?
	:arm:coun? xxx :arm:lay2:coun? xxx
	:trig:coun?
	:trig:coun? xxx
	where; xxx = def, min or max
Response messages:	1 to 99999 (for finite count)
	+9.9e37 (for infinite count)

Description

These commands are used to specify how many times operation will loop around in the specified layer of operation. For example, if the measure count is set to 10, operation will continue to loop around in the measure layer until 10 measurements are performed. After the 10th measurement, operation will proceed back up to the scan layer.

Programming example

```
10  OUTPUT 716; ":trig:coun  10; coun?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the measure count to 10, and then queries the programmed arm count.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed measure count (10).

4.24.5 :DELay <n>

:ARM[:SEQuence[1]]:LAYer2:DELay <n> Set scan layer delay
:TRIGger[:SEQuence[1]]:DELay <n> Set measure layer delay

Parameters

<n>	= 0 to 999999.999	Specify delay in seconds
	= DEFault	0 second delay
	= MINimum	0 second delay
	= MAXimum	999999.999 second delay

Formats

:arm:lay2:del <n>
:trig:del <n>

Defaults

Power-up	Saved power-on setup
*RST	0 sec (scan and measure layer)
:SYSTem:PRESet	0 sec (scan and measure layer)

Query

:DELay?	Query the programmed delay
:DELay? DEFault	Query the *RST default delay
:DELay? MINimum	Query the lowest allowable delay
:DELay? MAXimum	Query the largest allowable delay
Short-form formats:	:arm:lay2:del? :trig:del?
	:arm:lay2:del? xxx :trig:del? xxx
	where; xxx = def, min or max
Response message:	0 to 999999.999 (seconds)

Description

These delay periods are used to delay operation in the specified layer. After the programmed event occurs, the instrument will wait until the delay period expires before proceeding on in the Trigger Model.

Note that the arm layer does use a Delay.

Programming example

```
10  OUTPUT 716; ":trig:del  1; del?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets a one second delay for the measure layer, and then queries the programmed delay.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed delay (1).

4.24.6 :SOURce <name>

:ARM[:SEQuence[1]][:LAYer[1]]:SOURce <name>	Specify arm event control source
:ARM[:SEQuence[1]]:LAYer2:SOURce <name>	Specify scan event control source
:TRIGger[:SEQuence[1]]:SOURce <name>	Specify measure event control source

Parameters

<name>	= HOLD	Hold operation in specified layer
	= IMMediate	Pass operation through specified layer
	= MANual	Select manual event
	= BUS	Select GPIB trigger as event
	= TLINk	Select Trigger Link as event
	= EXTernal	Select External Triggering as event
	= TIMer	Select timer as event (not available for arm layer).

Formats

:arm:sour <name>
:arm:lay2:sour <name>
:trig:sour <name>

Defaults

Power-up	Saved power-on setup
*RST	IMMediate (all layers)
:SYSTem:PRESet	IMMediate (all layers)

Query

:SOURce?	Query programmed arm source.
Short-form formats:	:arm:sour?
	:arm:lay2?
	:trig:sour?
Response message:	HOLD, MAN, IMM, BUS, TLIN, EXT or TIM

Description

These commands are used to select the event control source the specified layer. With HOLD selected, operation will stop and wait indefinitely in the specified layer. While in HOLD, operation can be continued by sending the :IMMediate command or the :SIGNal command. Keep in mind however, that if the layer count is >1, HOLD will again be enforced when operation loops back around.

With IMMediate selected (do not confuse :SOURce IMMediate with :IMMediate), operation will immediately pass through the specified layer.

A specific event can be used to control operation through a layer. With BUS selected, operation will continue when a GPIB trigger (GET or *TRG) is sent. With TLINk selected, operation will continue when an input trigger via the Trigger Link is received. With EXTernal selected, operation will continue when an External Trigger is received.

A TIMer event is available for the scan and measure layers. With TIMer selected for the specified layer, the event occurs at the beginning of the timer interval, and every time it times out. For example, if the measure layer timer is programmed for a 30 second interval, the first pass through the measure layer control source will occur immediately. Subsequent scan events will then occur every 30 seconds. The interval for the timer is set using the :TIMer command.

Programming example

```
10  OUTPUT 716; ":trig:sour  imm; sour?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the measure control source to immediate, and then queries the programmed control source.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed measure control source (IMM).

4.24.7 :TIMer <n>

:ARM:[SEQuence[1]]:LAYer2:TIMer <n> Set interval for scan layer timer
:TRIGger:[SEQuence[1]]:TIMer <n> Set interval for measure layer timer

Parameters

<n>	= 0.001 to 999999.999	Specify timer interval in seconds
	= DEFault	0.1 second
	= MINimum	0.001 second
	= MAXimum	999999.999 seconds

Formats

:arm:lay2:tim <n>
:trig:tim <n>

Defaults

Power-up	Saved power-on setup
*RST	measure layer timer; 0.1 second
	scan layer timer; 1 second
:SYSTem:PRESet	Same as *RST

Query

:TIMer?	Query programmed timer interval
:TIMer? DEFault	Query *RST default timer interval
:TIMer? MINimum	Query lowest allowable timer interval
:TIMer? MAXimum	Query largest allowable timer interval
Short-form formats:	:arm:lay2:tim?
	:arm:lay2:tim? xxx
	:trig:tim?
	:trig:tim? xxx
	where; xxx = def, min or max
Response message:	.001 to 999999.999

Description

These commands are used to set the interval for the scan layer and measure layer timers. Note that the timer is in effect only if the timer is the selected control source. Also, note that the arm layer does not use a timer.

Programming example

```
10  OUTPUT 716; ":trig:tim  0.25; tim?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Sets the measure layer timer for a ¼ second interval, and then queries the programmed timer interval.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the timer interval (.25).

4.24.8 :SIGNal

:ARM[:SEQuence[1]][:LAYer[1]]:SIGNal	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:SIGNal	Bypass scan control source
:TRIGger[:SEQuence[1]]:SIGNal	Bypass measure control source

Format :arm:sign

Description These action commands are used to bypass the specified control source and also when you do not wish to wait for the programmed event. Keep in mind that the instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and this command will be ignored.

When this command is sent, the specified control source will be bypassed. This will allow operation to continue.

Note that :SIGNal is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the control source.

Programming example

```
OUTPUT 716; ":trig:sign"          ! Bypass measure control source.
```

4.24.9 TCONfigure commands

:PROTocol <name>

:TRIGger[:SEQuence[1]]:TCONfigure:PROTocol <name> Specify Trigger Link protocol

Parameters

<name>	= ASYNchronous	Asynchronous Trigger Link mode
	= SSYNchronous	Semi-synchronous Trigger Link mode

Format :trig:tcon:prot <name>

Defaults

Power-up	Saved power-on setup
*RST	ASYNchronous
:SYSTem:PRESet	ASYNchronous

Query

:PROTocol?	Query programmed Trigger Link protocol
Short-form format:	:trig:tcon:prot?
Response message:	ASYN or SSYN

Description This command is used to select the protocol for the measure layer Trigger Link. With ASYNchronous selected, separate trigger lines are used for input and output triggers. With SSYNchronous selected, a single trigger line is used for both input and output triggers.

Note that the arm and scan layers only use the asynchronous Trigger Link mode and therefore, do not have to be selected.

Programming example

```
10  OUTPUT 716; ":trig:tcon:prot  ssyn; prot?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Selects semi-synchronous Trigger Link protocol, and then queries the selected protocol.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the Trigger Link protocol (SSYN).

:DIRection <name>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:DIRection <name>	Control arm Source Bypass
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:DIRection <name>	Control scan Source Bypass
:TRIGger[:SEQuence[1]]:TCONfigure:DIRection <name>	Control measure Source Bypass

Parameters

<name>	= SOURce	Enable Source Bypass
	= ACCeptor	Disable Source Bypass

Formats

:arm:tcon:dir <name>
:arm:lay2:tcon:dir <name>
:trig:tcon:dir <name>

Defaults

Power-up	Saved power-on setup
*RST	ACCeptor (all layers)
:SYSTem:PRESet	ACCeptor (all layers)

Query

:DIRection?	Query Source Bypass state
Short-form formats:	:arm:tcon:dir?
	:arm:lay2:tcon:dir?
	:trig:tcon:dir?
Response message:	SOUR or ACC

Description

When a Source Bypass is enabled and the External or Trigger Link arm control source is selected, operation will loop around the appropriate control source on the initial pass through that layer. Note that the Source Bypass for the scan and measure layers also loops around the Delay.

If programmed for another pass through the specified layer (count >1), the bypass loop will not be in effect even though it will still be enabled. The bypass loop will be in effect if operation first goes back into the previous layer (or idle).

Enabling the Source Bypass for the arm and scan layers also enables their Output Triggers. When operation leaves the arm or scan layer, the appropriate output trigger pulse will occur. If the Trigger Link (TLINk) control source is selected, the output trigger will be available on the programmed Trigger Link output line. For all other control source selections, the output trigger pulse will be available at the METER COMPLETE Output connector. The Output Trigger in these two layers is disabled when the Source Bypass is disabled.

The Output Trigger in the measure layer is always enabled and occurs after the Device Action.

With ACCeptor selected, the bypass is disabled, This simply means that operation will not proceed through the specified layer until the appropriate event occurs.

Programming example

```
10  OUTPUT 716; ":trig:tcon:dir  sour; dir?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Enables the Source Bypass for the measure layer and then queries the state of the Source Bypass.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the state of the Source Bypass (SOUR; enabled).

:ASYNchronous commands

:ILINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; arm layer
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; scan layer
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; measure layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Formats

```
:arm:tcon:asyn:ilin  <NRf>
:arm:lay2:tcon:asyn:ilin  <NRf>
:trig:tcon:asyn:ilin  <NRf>
```

Defaults

Power-up	Saved power-on setup
*RST	2 (all layers)
:SYSTem:PRESet	2 (all layers)

Query

:ILINe?	Query programmed input line #
Short-form format:	:arm:tcon:asyn:ilin?
	:arm:lay2:tcon:asyn:ilin?
	:trig:tcon:asyn:ilin?
Response message:	1 to 6

Description

These commands are used to select an input line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output (see :OLINe) cannot share the same line. If you assign the input to a line that is already being used for the output, an error will occur and the command will be ignored.

Programming example

```
10  OUTPUT 716; ":trig:tcon:asyn:ilin  3; ilin?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Assigns the asynchronous Trigger Link input of the measure layer to line #3, and then queries the programmed input line.

Line 20 Addresses the Model 2001 to talk.

Line 30 Displays the programmed input line # (3).

:OLINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; arm layer
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; scan layer
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; measure layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Formats

```
:arm:tcon:asyn:olin  <NRf>
:arm:lay2:tcon:asyn:olin  <NRf>
:trig:tcon:asyn:olin  <NRf>
```

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (all layers)

Query

:OLINe?	Query programmed output line #
Short-form formats:	:arm:tcon:asyn:olin?
	:arm:lay2:tcon:asyn:olin?
	:trig:tcon:asyn:olin?
Response message:	1 to 6

Description

These commands are used to select an output line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output cannot share the same line. If you assign the output to a line that is already being used for the input, an error will occur and the command will be ignored.

Programming example

```
10  OUTPUT 716; ":trig:tcon:asyn:olin 4; olin?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Assigns the asynchronous Trigger Link output of the measure layer to line #4, and then queries the programmed output line.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the programmed output line # (4).

:SSYNchronous:LINE <NRf>

:TRIGger[:SEQuence[1]]:TCONfigure:SSYNchronous :LINE <NRf> — Specify semi-synchronous Trigger Link line for measure layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Format

:trig:tcon:ssyn:line <NRf>

Defaults

Power-up	Saved power-on setup
*RST	1 (measure layer)
:SYSTem:PRESet	1 (measure layer)

Query

:LINE?	Query programmed output line #
Short-form format:	:trig:tcon:ssyn:line?
Response message:	1 to 6

Description

This command is used to select one of the six trigger lines for the semi-synchronous Trigger Link.

Programming example

```
10 OUTPUT 716; ":trig:tcon:ssyn:line 6; line?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Selects line #6 for the Trigger Link, and then queries the programmed line number.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays selected line number (6).

4.25 :UNIT subsystem

The UNIT subsystem is used to configure and control the measurement units for TEMP and ACV, and is summarized in Table 4-33.

Table 4-33
UNIT command summary

Command	Description
:UNIT	
:TEMPerature <name>	Select temperature measurement units: C, CEL, F, FAR, K.
:TEMPerature?	Query temperature units.
:VOLTage	Path to configure ACV units.
:AC <name>	Select ACV measurement units: V, DB, DBM.
:DB	Path to set DB reference voltage.
:REFerence <n>	Specify reference in volts.
:REFerence?	Query DB reference.
:DBM	Path to set DBM reference impedance.
:IMPedance <n>	Specify reference impedance.
:IMPedance?	Query DBM reference impedance.
:AC?	Query ACV units

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

:TEMPerature <name>

:UNIT:TEMPerature <name> Specify TEMP units

Parameters

<name>	= C or CEL	°C temperature units
	= F or FAR	°F temperature units
	= K	K temperature units

Format :unit:temp <name>

Defaults

Power-up	Saved power-on setup
*RST	C temperature units
:SYSTem:PRESet	C temperature units

Description This command is used to specify the units for temperature measurements.

Programming example

```
OUTPUT 716; ":unit:temp f"      ! Display temp in °F
```

:AC <name>

:UNIT:VOLTage:AC <name> Specify ACV units

Parameters

<name>	= V	AC voltage measurement units
	= DB	dB AC voltage measurement units
	= DBM	dBm AC voltage measurement units

Format :unit:volt:ac <name>

Defaults

Power-up	Saved power-on setup
*RST	V
:SYSTem:PRESet	V

Query

:AC?	Query AC voltage units
Short-form format:	:unit:volt:ac?
Response message:	V, DB or DBM

Description This command is used to select the units for ACV measurements. With volt (V) units selected, normal AC voltage measurements will be made for the ACV function.

With DB units selected, AC dB voltage measurements are calculated according to the following equation:

$$dB = 20 \log \frac{V_{IN}}{V_{REF}}$$

where; V_{IN} is the AC input signal.
V_{REF} is the specified reference level in volts.

The dB reference level (V_{REF}) is specified using the :DB:REFerence <n> command. Note that any AC type can be used for dB or dBm measurements except Positive and Negative Peak. These functions may return negative values. The log of a negative number is undefined.

The DBM units selection is used to make decibel measurements referenced to 1mW and can be expressed as follows:

$$dBm = 10 \log \frac{P}{1mW}$$

$$P = \frac{V_{IN}^2}{Z_{REF}}$$

where; V_{IN} is the AC input signal.
Z_{REF} is the specified dBm reference impedance.

The dBm reference impedance (Z_{REF}) is specified using the :DBM:IMPedance <n> command. Note that any AC type (except Positive and Negative Peak) can be used for dbm measurements.

Programming example

```
10  OUTPUT 716; ":unit:volt:ac  db; ac?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects dB units for ACV measurements, and the second queries units.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the selected units (DB).

:DB:REFerence <n>

:UNIT:VOLTage:AC:DB:REFerence <n> Specify dBm reference

Parameters

<n>	= 0.001 to 750	Specify reference in volts
	= DEFault	1V reference
	= MINimum	0.001V reference
	= MAXimum	750V reference

Format

:unit:volt:ac:db:ref <n>

Defaults

Power-up	Saved power-on setup
*RST	1V
:SYSTem:PRESet	1V

:REFerence?
:REFerence? DEFault
:REFerence? MINimum
:REFerence? MAXimum

Short-form formats:
:unit:volt:ac:db:ref?
:unit:volt:ac:db:ref? def
:unit:volt:ac:db:ref? min
:unit:volt:ac:db:ref? max

Response message: 0.001 to 750

Description

This command is used to specify the dB reference level. When DB units is selected (:VOLTage:AC: DB), ACV db measurements will be made using the specified dB reference level.

The reference level is specified in volts and is not range dependent. For example, a dB reference level of 1 is 1V on all ACV measurement ranges.

Programming example

```
10 OUTPUT 716; ":unit:volt:ac:db:ref 2; ref?"
20 ENTER 716; A$
30 PRINT A$
40 END
```

Line 10 Two commands in this program message; the first sets the dB reference level to 2V, and the second queries the reference level.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the reference level (2).

:DBM:IMPedance <n>

:UNIT:VOLTage:AC:DBM:IMPedance <n> Specify dB reference

Parameters

<n>	= 50	50Ω reference impedance
	= 75	75Ω reference impedance
	= 93	93Ω reference impedance
	= 132	132Ω reference impedance
	= 300	300Ω reference impedance
	= 600	600Ω reference impedance
	= DEFault	75Ω reference impedance
	= MINimum	50Ω reference impedance
	= MAXimum	600Ω reference impedance

Format

:unit:volt:ac:dbm:imp <n>

Defaults

Power-up	Saved power-on setup
*RST	75Ω
:SYSTem:PRESet	75Ω

Query

:IMPedance?
:IMPedance? DEFault
:IMPedance? MINimum
:IMPedance? MAXimum

Short-form formats:	:unit:volt:ac:dbm:imp?
	:unit:volt:ac:dbm:imp? def
	:unit:volt:ac:dbm:imp? min
	:unit:volt:ac:dbm:imp? max
Response message:	50 to 600 (ohms)

Description

This command is used to specify the dBm reference impedance level. When dBm units is selected ACV dBm measurements will be made using the specified dBm reference impedance.

The reference impedance is specified in ohms and is not range dependent. For example, a dBm reference level of 600 is 600Ω on all ACV measurement ranges. Specifying a value that is not listed above will be rounded to the nearest valid value.

Programming example

```
10  OUTPUT 716; ":unit:volt:ac:dbm:imp  600; imp?"
20  ENTER 716; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first sets the dBm reference impedance to 600Ω, and the second queries the reference impedance.
Line 20 Addresses the Model 2001 to talk.
Line 30 Displays the reference impedance (600).

A

Specifications

Model 2001 Specifications

The following pages contain the complete specifications for the 2001. Every effort has been made to make these specifications complete by characterizing its performance under the variety of conditions often encountered in production, engineering and research.

The 2001 provides 5-minute, 1-hour, 24-hour, 90-day, 1-year, and 2-year specifications, with full specifications for the 90-day, 1-year and 2-year specifications. This allows the user to utilize 90-day, 1-year, or 2-year recommended calibration intervals, depending upon the level of accuracy desired. As a general rule, the 2001's 2-year performance exceeds a 5½-digit DMM's 90-day, 180-day or 1-year specifications. 6½- or 7½-digit performance is assured using 90-day or 1-year specifications.

ABSOLUTE ACCURACY

To minimize confusion, *all 90-day, 1-year and 2-year 2001 specifications are absolute accuracy,* traceable to NIST based on factory calibration. Higher accuracies are possible, based on your calibration sources. For example, calibrating with a 10V primary standard rather than a 20V calibrator will reduce calibration uncertainty, and can thereby improve total 2001 accuracy for measurements up to 50% of range. Refer to the 2001 calibration procedure for details.

TYPICAL ACCURACIES

Accuracy can be specified as typical or warranted. All specifications shown are warranted unless specifically noted.

Almost 99% of the 2001's specifications are warranted specifications. In some cases it is not possible to obtain sources to maintain traceability on the performance of every unit in production on some measurements (e.g., high-voltage, high-frequency signal sources with sufficient accuracy do not exist). Since these values cannot be verified in production, the values are listed as typical.

2001 SPECIFIED CALIBRATION INTERVALS

MEASUREMENT FUNCTION	24 HOUR[1]	90 DAY[2]	1 YEAR[2]	2 YEAR[2]
DC Volts	•	•	•	•
DC Volts Peak Spikes		•[3]	•	•
AC Volts rms		•[3]	•	•
AC Volts Peak		•[3]	•	•
AC Volts Average		•[3]	•	•
AC Volts Crest Factor		•[3]	•	•
Ohms	•	•	•	•
DC Current	•	•	•	•
DC In-Circuit Current		•	•	•
AC Current		•[3]	•	•
Frequency		•	•	•
Temperature (Thermocouple)		•	•	•
Temperature (RTD)		•	•	•

[1] For T_{CAL} ±1°C.
[2] For T_{CAL} ±5°C.
[3] For ±2°C of last AC self cal.

DCV INPUT CHARACTERISTICS AND ACCURACY

RANGE	FULL SCALE	RESOLUTION	DEFAULT RESOLUTION	INPUT RESISTANCE	ACCURACY[1] ± (ppm of reading + ppm of range) 5 Minutes[12]	24 Hours[2]	90 Days[3]	1 Year[3]	2 Years[3]	TEMPERATURE COEFFICIENT ± (ppm of reading + ppm of range)/°C Outside TCAL ± 5°C
200 mV[4]	±210.00000	10 nV	100 nV	>10 GΩ	3 + 3	10 + 6	25 + 6	37 + 6	50 + 6	3.3 +1.5
2 V	±2.1000000	100 nV	1 µV	>10 GΩ	2 + 1.5	7 + 2	18 + 2	25 + 2	32 + 2	2.6 +0.15
20 V	±21.000000	1 µV	10 µV	>10 GΩ	2 + 1.5	7 + 4	18 + 4	24 + 4	32 + 4	2.6 +0.7
200 V	±210.00000	10 µV	100 µV	10 MΩ ±1%	2 + 1.5	13 + 3	27 + 3	38 + 3	52 + 3	4.3 +1
1000 V	±1100.0000	100 µV	1 mV	10 MΩ ±1%	10 + 1.5	17 + 6	31 + 6	41 + 6	55 + 6	4.1 +1

DC VOLTAGE UNCERTAINTY = ±[(ppm of reading) × (measured value) + (ppm of range) × (range used)] / 1,000,000.

% ACCURACY = (ppm accuracy) /10,000.

1PPM OF RANGE = 2 counts for ranges up to 200V, 1 count on 1000V range at 6½ digits.

SPEED AND ACCURACY[5]

90 Days

RANGE	ACCURACY ± (ppm of reading+ppm of range+ppm of range rms noise[10]) 1PLC DFILT On, 10 Readings	1PLC DFILT Off	0.1PLC DFILT Off	0.01PLC[11] DFILT Off
200 mV[4]	25+6+0	25+6+0.6	25+30+10	100+200+15
2 V	18+2+0	18+2+0.2	18+25+1	130+200+3
20 V	18+4+0	18+4+0.3	18+20+0.5	130+200+3
200 V	27+3+0	27+5+0.3	27+20+0.8	130+200+3
1000 V	31+6+0	31+6+0.1	31+21+0.5	90+200+2

PLC = power line cycle; DFILT = digital filter

NOISE REJECTION (dB)

SPEED (Number of Power Line Cycles)	AC and DC CMRR[6] Line Sync On[7]	Internal Trigger[8]	AC NMRR Line Sync On[7] 25-Reading DFILT On	Line Sync On[7] DFILT Off	Internal Trigger[8] DFILT Off
NPLC = 10	140	120	90	80	60
NPLC ≥ 1	140	120	90	80	60
NPLC < 1	60	50	30	20	0

Effective noise is reduced by a factor of 10 for every 20dB of noise rejection (140dB reduces effective noise by 10,000,000:1).

CMRR is rejection of undesirable AC or DC signal between LO and earth. NMRR is rejection of undesirable AC signal between HI and LO.

DCV READING RATES[9,10]

200mV, 2V, 200V Ranges

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND TO IEEE-488 Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	7½	6 (5.1)	2 (1.7)	6	2 (1.6)	6 (4.1)	2 (1.6)
2	33.4 ms (40 ms)	26	7½	30 (25)	9 (7.6)	28 (23)	9 (7.3)	27 (22)	8 (7.2)
1	16.7 ms (20 ms)	25	6½	58 (48)	44 (34)	54 (45)	41 (32)	49 (41)	37 (30)
0.2	3.34 ms (4 ms)	22	6½	214 (186)	127 (112)	183 (162)	104 (101)	140 (126)	88 (85)
0.1	1.67 ms (2 ms)	21	5½	272 (272)	150 (148)	228 (225)	129 (123)	156 (153)	100 (96)
0.02	334 µs (400 µs)	19	5½	284 (287)	156 (155)	230 (230)	136 (134)	158 (156)	104 (103)
0.01	167 µs (167 µs)	16	4½	417 (417)	157 (157)	317 (317)	137 (134)	198 (198)	105 (103)
0.01[11]	167 µs (167 µs)	16	4½	2000 (2000)		2000 (2000)			

20V, 1000V Ranges

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND TO IEEE-488 Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	7½	6 (5.1)	2 (1.7)	6	2 (1.6)	6	2 (1.6)
2	33.4 ms (40 ms)	26	7½	30 (25)	9 (8.2)	28 (23)	9 (7.8)	27 (22)	9 (7.7)
1	16.7 ms (20 ms)	25	6½	57 (48)	42 (38)	54 (45)	43 (35)	48 (41)	39 (32)
0.2	3.34 ms (4 ms)	22	6½	201 (186)	102 (113)	173 (162)	102 (99)	129 (127)	84 (83)
0.1	1.67 ms (2 ms)	21	5½	201 (201)	126 (116)	175 (173)	105 (105)	129 (128)	86 (86)
0.02	334 µs (400 µs)	19	5½	227 (227)	129 (129)	178 (178)	114 (114)	138 (138)	90 (90)
0.01	167 µs (167 µs)	16	4½	422 (422)	130 (130)	333 (333)	117 (117)	199 (199)	95 (95)
0.01[11]	167 µs (167 µs)	16	4½	2000 (2000)		2000 (2000)			

SETTLING CHARACTERISTICS: <500µs to 10ppm of step size. Reading settling times are affected by source impedance and cable dielectric absorption characteristics. Add 10ppm of range for first reading after range change.

ZERO STABILITY: Typical variation in zero reading, 1 hour, TREF ±1°C, 6½-digit default resolution, 10-reading digital filter:

Range	ZERO STABILITY 1 Power Line Cycle Integration	10 Power Line Cycle Integration
2V – 1000V	±3 counts	±2 counts
200 mV	±5 counts	±3 counts

ISOLATED POLARITY REVERSAL ERROR: This is the portion of the instrument error that is seen when high and low are reversed when driven by an isolated source. This is not an additional error—it is included in the overall instrument accuracy spec. **Reversal Error:** <2 counts at 10V input at 6½ digits, 10 power line cycles, 10-reading digital filter.

INPUT BIAS CURRENT: <100pA at 25°C.

LINEARITY: <1ppm of range typical, <2ppm maximum.

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

DC VOLTS NOTES

1. Specifications are for 1 power line cycle, Auto Zero on, 10-reading digital filter, except as noted.
2. For TCAL ±1°C, following 55-minute warm-up. TCAL is ambient temperature at calibration, which is 23°C from factory.
3. For TCAL ±5°C, following 55-minute warm-up. Specifications include factory traceability to US NIST.
4. When properly zeroed using REL function.
5. For TCAL ±5°C, 90-day accuracy. 1-year or 2-year accuracy can be found by applying the same speed accuracy ppm changes to the 1-year or 2-year base accuracy.
6. Applies for 1kΩ imbalance in the LO lead. For 400Hz operation, subtract 10dB.
7. For noise synchronous to the line frequency.
8. For line frequency ±0.1%.
9. See Operating Speed section for additional detail. For DELAY=0, internal trigger, digital filter off, display off (or display in "hold" mode). Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz).
10. Typical values.
11. In burst mode, display off. Burst mode requires Auto Zero refresh (by changing resolution or measurement function) once every 24 hours.
12. DCV Transfer Stability typical applications are standard cell comparisons and relative accuracy measurements. Specs apply for 10 power line cycles, 20-reading digital filter, autozero on with type synchronous, fixed range following 2-hour warm-up at full scale to 10% of full scale, at TREF ± 1°C (TREF is the initial ambient temperature). Specifications on the 1000V range are for measurements within 5% of the initial measurement value and following measurement settling.

DCV PEAK SPIKES MEASUREMENT

REPETITIVE SPIKES ACCURACY[1] 90 Days, ±2°C from last AC self-cal ± (% of reading+% of range)

RANGE	0–1kHz[4]	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–1MHz	TEMPERATURE COEFFICIENT ± (% of reading+% of range)/°C Outside T_{CAL} ± 2°C
200 mV	0.08+0.7	0.08+0.7	0.1 +0.7	0.15+0.7	0.25+0.7	1.0+ 0.7	2.5+ 0.7	5.5+ 0.7	9+ 0.7	0.002+0.03
2 V	0.08+0.3	0.08+0.3	0.1 +0.3	0.15+0.3	0.25+0.3	1.0+0.3	2.5+0.3	5.5+0.3	9+0.3	0.002+0.03
20 V	0.09+0.7	0.1 +0.7	0.12+0.7	0.17+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.004+0.03
200 V[3]	0.09+0.3	0.1 +0.3	0.12+0.3	0.17+0.3	0.25+0.3	1.0+0.3[2]	2.5+0.3[2]	5.5+0.3[2]	9+0.3[2]	0.004+0.03
1000 V[3]	0.1 +0.6	0.13+0.6	0.16+0.6	0.25+0.6[2]	0.5 +0.6[2]					0.01 +0.02
Max. % of Range	±125%	±125%	±125%	±125%	±125%	±125%	±125%	±100%	±75%	

REPETITIVE SPIKES ACCURACY[1] 1 or 2 Years, T_{CAL} ± 5°C ± (% of reading+% of range)

RANGE	0–1kHz[4]	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–1MHz	TEMPERATURE COEFFICIENT ± (% of reading+% of range)/°C Outside T_{CAL} ± 5°C
200 mV	0.08+0.7	0.09+0.7	0.1 +0.7	0.15+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.002+0.03
2 V	0.08+0.3	0.09+0.3	0.1 +0.3	0.15+0.3	0.25+0.3	1.0+0.3	2.5+0.3	5.5+0.3	9+0.3	0.002+0.03
20 V	0.1 +0.7	0.11+0.7	0.14+0.7	0.19+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.004+0.03
200 V[3]	0.1 +0.3	0.11+0.3	0.14+0.3	0.19+0.3	0.25+0.3	1.0+0.3[2]	2.5+0.3[2]	5.5+0.3[2]	9+0.3[2]	0.004+0.03
1000 V[3]	0.12+0.6	0.16+0.6	0.2 +0.6	0.25+0.6[2]	0.5 +0.6[2]					0.01 +0.02
Max. % of Range	±125%	±125%	±125%	±125%	±125%	±125%	±125%	±100%	±75%	

DEFAULT MEASUREMENT RESOLUTION: 3½ digits.

MAXIMUM INPUT: ±1100V peak value, 2×10^7V•Hz (for inputs above 20V).

NON-REPETITIVE SPIKES: 10% of range per µs typical slew rate.

SPIKE WIDTH: Specifications apply for spikes ≥1µs.

RANGE CONTROL: In Multiple Display mode, voltage range is the same as DCV range.

SPIKES MEASUREMENT WINDOW: Default is 100ms per reading (settable from 0.1 to 9.9s in Primary Display mode).

INPUT CHARACTERISTICS: Same as ACV input characteristics.

SPIKES DISPLAY: Access as multiple display on DC Volts. First option presents positive peak spikes and highest spike since reset. Second option presents negative spikes and lowest spike. Highest and lowest spike can be reset by pressing DCV function button. Third option displays the maximum and minimum levels of the input signal. Spikes displays are also available through CONFIG-ACV-ACTYPE as primary displays.

DCV PEAK SPIKES NOTES

1. Specifications apply for 10-reading digital filter. If no filter is used, add 0.25% of range typical uncertainty.
2. Typical values.
3. Add 0.001% of reading × $(V_{IN}/100V)^2$ additional uncertainty for inputs above 100V.
4. Specifications assume AC+DC coupling for frequencies below 200Hz. Below 20Hz add 0.1% of reading additional uncertainty.

AC VOLTS

AC magnitude: RMS or Average. Peak and Crest Factor measurements also available.

ACV INPUT CHARACTERISTICS

RMS RANGE	PEAK INPUT	FULL SCALE RMS	RESOLUTION	DEFAULT RESOLUTION	INPUT IMPEDANCE	TEMPERATURE COEFFICIENT[2] ± (% of reading + % of range) / °C Outside T_{CAL} ± 5°C
200 mV	1 V	210.0000	100 nV	1 µV	1MΩ ±2% with <140pF	0.004 + 0.001
2 V	8V	2.100000	1 µV	10 µV	1MΩ ±2% with <140pF	0.004 + 0.001
20 V	100 V	21.00000	10 µV	100 µV	1MΩ ±2% with <140pF	0.006 + 0.001
200 V	800 V	210.0000	100 µV	1 mV	1MΩ ±2% with <140pF	0.006 + 0.001
750 V	1100 V	775.000	1 mV	10 mV	1MΩ ±2% with <140pF	0.012 + 0.001

AC VOLTAGE UNCERTAINTY = ±[(% of reading) × (measured value) + (% of range) × (range used)] / 100.

PPM ACCURACY = (% accuracy) × 10,000.

0.015% OF RANGE = 30 counts for ranges up to 200V and 113 counts on 750V range at 5½ digits.

LOW FREQUENCY MODE RMS[1] 90 Days, ±2°C from last AC self-cal, for 1% to 100% of range[3] ± (% of reading + % of range)

RANGE	1–10Hz[5]	10–50Hz	50–100Hz	0.1–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200 mV	0.09+0.015	0.04+0.015	0.03+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2 V	0.09+0.015	0.04+0.015	0.03+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20 V	0.1 +0.015	0.05+0.015	0.04+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[6]
200 V[4]	0.1 +0.015	0.05+0.015	0.04+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025[6]	4+0.2[6]	
750 V[4]	0.13+0.015	0.09+0.015	0.08+0.015	0.08+0.015	0.09+0.015	0.12 +0.015	0.15+0.015[5]	0.5+0.015[5]			

LOW FREQUENCY MODE RMS[1] 1 or 2 Years, T_{CAL} ± 5°C for 1% to 100% of range[3] ± (% of reading + % of range)

RANGE	1–10Hz[5]	10–50Hz	50–100Hz	0.1–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200 mV	0.11+0.015	0.06+0.015	0.05+0.015	0.05+0.015	0.05 +0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2 V	0.11+0.015	0.06+0.015	0.05+0.015	0.05+0.015	0.05 +0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20 V	0.12+0.015	0.07+0.015	0.06+0.015	0.06+0.015	0.085+0.015	0.12+0.015	0.13+0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[6]
200 V[4]	0.12+0.015	0.07+0.015	0.06+0.015	0.06+0.015	0.085+0.015	0.12+0.015	0.13+0.015	0.3+0.015	0.75+0.025[6]	4+0.2[6]	
750 V[4]	0.15+0.015	0.11+0.015	0.1 +0.015	0.1 +0.015	0.13 +0.015	0.18+0.015	0.22+0.015[5]	0.5+0.015[5]			

AC VOLTS (cont'd)

NORMAL MODE RMS[1]

90 Days, ±2°C from last AC self-cal for 1% to 100% of range[3] ±(% of reading + % of range)

RANGE	20–50Hz	50–100Hz	0.1–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200 mV	0.25+0.015	0.07+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2 V	0.25+0.015	0.07+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20 V	0.25+0.015	0.07+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[5]
200 V[4]	0.25+0.015	0.07+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025[6]	4+0.2[6]	
750 V[4]	0.25+0.015	0.1 +0.015	0.08+0.015	0.09+0.015	0.12 +0.015	0.15+0.015[5]	0.5+0.015[5]			

NORMAL MODE RMS[1]

1 or 2 Years, T_{CAL} ±5°C for 1% to 100% of range[3] ±(% of reading + % of range)

RANGE	20–50Hz	50–100Hz	0.1–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200 mV	0.25+0.015	0.08+0.015	0.05+0.015	0.05 +0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2 V	0.25+0.015	0.08+0.015	0.05+0.015	0.05 +0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20 V	0.25+0.015	0.08+0.015	0.06+0.015	0.085+0.015	0.12+0.015	0.13+0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[5]
200 V[4]	0.25+0.015	0.08+0.015	0.06+0.015	0.085+0.015	0.12+0.015	0.13+0.015	0.3+0.015	0.75+0.025[6]	4+0.2[6]	
750 V[4]	0.27+0.015	0.11+0.015	0.1 +0.015	0.13 +0.015	0.18+0.015	0.22+0.015[5]	0.5+0.015[5]			

dB ACCURACY RMS

±dB, 90 Days, 1 or 2 Years, T_{CAL} ±5°C, Reference=1V, Autoranging, Low Frequency Mode, AC+DC Coupling

INPUT	1–100Hz	0.1–30kHz	30–100kHz	100–200kHz	0.2–1MHz	1–2MHz
–54 to–40 dB (2 mV to 10 mV)	0.230	0.225	0.236	0.355		
–40 to–34 dB (10 mV to 20 mV)	0.036	0.031	0.041	0.088		
–34 to 6 dB (20 mV to 2 V)	0.023	0.018	0.028	0.066	0.265	0.630
6 to 26 dB (2 V to 20 V)	0.024	0.024	0.028	0.066	0.538	0.820[5]
26 to 46 dB (20 V to 200 V)	0.024	0.024	0.028	0.066[5]	0.538[5]	
46 to 57.8 dB (200 V to 775 V)	0.018	0.021	0.049[5]			

ACV READING RATES[5,6]

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND TO IEEE-488 Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	6½	6 (5.1)	2 (1.7)	2	2 (1.6)	2	2 (1.5)
2	33.4 ms (40 ms)	26	5½	30 (24)	9 (7.9)	28 (23)	9 (7.6)	27 (22)	9 (7.5)
1	16.7 ms (20 ms)	25	5½	57 (48)	38 (35)	53 (45)	36 (33)	48 (41)	34 (30)
0.1	1.67 ms (2 ms)	21	5½	136 (136)	70 (70)	122 (122)	64 (64)	98 (98)	56 (56)
0.01	167 µs (167 µs)	16	4½	140 (140)	71 (71)	127 (127)	66 (66)	99 (99)	58 (58)
0.01[8]	167 µs (167 µs)	16	4½	2000 (2000)		2000 (2000)			

AC COUPLING:

For AC only coupling, add the following % of reading:

	1–10Hz	10–20Hz	20–50Hz	50–100Hz	100–200Hz
Normal Mode (rms, average)	—	—	0.41	0.07	0.015
Low Frequency Mode (rms)	0.1	0.01	0	0	0

For low frequency mode below 200Hz, specifications apply for sine wave inputs only.

AC+DC COUPLING:

For DC>20% of AC rms voltage, apply the following additional uncertainty, multiplied by the ratio (DC/AC rms). Applies to rms and average measurements.

RANGE	% of Reading	% of Range
200mV, 20V	0.05	0.1
2V, 200V, 750V	0.07	0.01

AVERAGE ACV MEASUREMENT

Normal mode rms specifications apply from 10% to 100% of range, for 20Hz–1MHz. Add 0.025% of range for 50kHz–100kHz, 0.05% of range for 100kHz–200kHz, and 0.5% of range for 200kHz–1MHz.

ACV CREST FACTOR MEASUREMENT[11]

CREST FACTOR = Peak AC / rms AC.

CREST FACTOR RESOLUTION: 3 digits.

CREST FACTOR ACCURACY: Peak AC uncertainty + AC normal mode rms uncertainty.

MEASUREMENT TIME: 100ms plus rms measurement time.

INPUT CHARACTERISTICS: Same as ACV input.

CREST FACTOR FREQUENCY RANGE: 20Hz – 1MHz.

CREST FACTOR DISPLAY: Access as multiple display on AC volts.

HIGH CREST FACTOR ADDITIONAL ERROR ±(% of reading)

Applies to rms measurements.

CREST FACTOR:	1 – 2	2 – 3	3 – 4	4 – 5
ADDITIONAL ERROR:	0	0.1	0.2	0.4

ACV PEAK VALUE MEASUREMENT[10]

REPETITIVE PEAK ACCURACY, ±(% of reading+% of range), 90 Days, 1 Year or 2 Years, T_{CAL} ±5°C

RANGE	20Hz–1kHz[9]	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–1MHz	TEMPERATURE COEFFICIENT ±(% of reading+% of range)/°C Outside T_{CAL} ±5°C
200 mV	0.08+0.7	0.09+0.7	0.1 +0.7	0.15+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.002 + 0.03
2 V	0.08+0.3	0.09+0.3	0.1 +0.3	0.15+0.3	0.25+0.3	1.0+0.3	2.5+0.3	5.5+0.3	9+0.3	0.002 + 0.03
20 V	0.1 +0.7	0.11+0.7	0.14+0.7	0.19+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.004 + 0.03
200 V[4]	0.1 +0.3	0.11+0.3	0.14+0.3	0.19+0.3	0.25+0.3	1.0+0.3[5]	2.5+0.3[5]	5.5+0.3[5]	9+0.3[5]	0.004 + 0.03
750 V[4]	0.12+0.6	0.16+0.6	0.2 +0.6	0.25+0.6[5]	0.5 +0.6[5]					0.01 + 0.02
Valid % of Range[7]	10–400%	10–400%	10–400%	10–350%	10–350%	10–250%	10–150%	10–100%	7.5–75%	

DEFAULT MEASUREMENT RESOLUTION: 4 digits.

NON-REPETITIVE PEAK: 10% of range per µs typical slew rate for single spikes.

PEAK WIDTH: Specifications apply for all peaks ≥1µs.

PEAK MEASUREMENT WINDOW: 100ms per reading.

MAXIMUM INPUT: ±1100V peak, 2×10^7V•Hz (for inputs above 20V).

AC VOLTS (cont'd)

SETTLING CHARACTERISTICS:

Normal Mode (rms, avg.)	<300ms to 1% of step change <450ms to 0.1% of step change <500ms to 0.01% of step change
Low Frequency Mode (rms)	<5s to 0.1% of final value

COMMON MODE REJECTION: For 1kΩ imbalance in either lead: >60dB for line frequency ±0.1%.

MAXIMUM VOLT•Hz PRODUCT: 2×10^7V•Hz (for inputs above 20V).

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

AC VOLTS NOTES

1. Specifications apply for sinewave input, AC + DC coupling, 1 power line cycle, digital filter off, following 55 minute warm-up.
2. Temperature coefficient applies to rms or average readings. For frequencies above 100kHz, add 0.01% of reading/°C to temperature coefficient.
3. For 1% to 5% of range below 750V range, and for 1% to 7% of 750V range, add 0.01% to range uncertainty. For inputs from 200kHz to 2MHz, specifications apply above 10% of range.
4. Add 0.001% of reading × $(V_{IN}/100V)^2$ additional uncertainty above 100V rms.
5. Typical values.
6. For DELAY=0, digital filter off, display off (or display in "hold" mode). Internal Trigger, Normal mode. See Operating Speed section for additional detail. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz). Applies for rms and average mode. Low frequency mode rate is typically 0.2 readings per second.
7. For overrange readings 200–300% of range, add 0.1% of reading. For 300–400% of range, add 0.2% of reading.
8. In burst mode, display off. Burst mode requires Auto Zero refresh (by changing resolution or measurement function) once every 24 hours.
9. AC peak specifications assume AC + DC coupling for frequencies below 200Hz.
10. Specifications apply for 10 reading digital filter. If no filter is used, add 0.25% of range typical uncertainty.
11. Subject to peak input voltage specification.

OHMS

TWO-WIRE AND FOUR-WIRE OHMS (2W and 4W Ohms Functions)[13]

RANGE	FULL SCALE	RESOLUTION	DEFAULT RESOLUTION	CURRENT[1] SOURCE	OPEN CIRCUIT[12]	MAXIMUM LEAD RESISTANCE[2]	MAXIMUM OFFSET COMPENSATION[3]	TEMPERATURE COEFFICIENT ± (ppm of reading + ppm of range)/°C Outside T_{CAL} ± 5°
20 Ω	21.000000	1 μΩ	10 μΩ	9.2 mA	5 V	1.7 Ω	±0.2 V	8 + 1.5
200 Ω	210.00000	10 μΩ	100 μΩ	0.98 mA	5 V	12 Ω	±0.2 V	4 + 1.5
2 kΩ	2100.0000	100 μΩ	1 mΩ	0.98 mA	5 V	100 Ω	–0.2 V to +2 V	3.0 + 0.2
20 kΩ	21.000000	1 mΩ	10 mΩ	89 μA	5 V	1.5 kΩ	–0.2 V to +2 V	4 + 0.2
200 kΩ	210.00000	10 mΩ	100 mΩ	7 μA	5 V	1.5 kΩ		11 + 0.2
2 MΩ[4]	2.1000000	100 mΩ	1 Ω	770 nA	5 V	1.5 kΩ		25 + 0.2
20 MΩ[4]	21.000000	1 Ω	10 Ω	70 nA	5 V	1.5 kΩ		250 + 0.2
200 MΩ[4]	210.00000	10 Ω	100 Ω	4.4 nA	5 V	1.5 kΩ		4000 + 10
1 GΩ[4]	1.0500000	100 Ω	1 kΩ	4.4 nA	5 V	1.5 kΩ		4000 + 10

RESISTANCE ACCURACY[5] ± (ppm of reading + ppm of range)

RANGE	24 Hours[6]	90 Days[7]	1 Year[7]	2 Years[7]
20 Ω	29 + 7	52 + 7	72 + 7	110 + 7
200 Ω	24 + 7	36 + 7	56 + 7	90 + 7
2 kΩ	22 + 4	33 + 4	50 + 4	80 + 4.5
20 kΩ	19 + 4	32 + 4	50 + 4	80 + 4.5
200 kΩ	20 + 4.5	72 + 4.5	90 + 4.5	130 + 5
2 MΩ[4]	50 + 4.5	110 + 4.5	160 + 4.5	230 + 5
20 MΩ[4]	160 + 4.5	560 + 4.5	900 + 4.5	1100 + 5
200 MΩ[4]	3000 + 100	10000 + 100	20000 + 100	30000 + 100
1 GΩ[4]	9000 + 100	20000 + 100	40000 + 100	60000 + 100

RESISTANCE UNCERTAINTY = ± [(ppm of reading) × (measured value) + (ppm of range) × (range used)] / 1,000,000.

% ACCURACY = (ppm accuracy) / 10,000.

1 PPM OF RANGE = 2 counts for ranges up to 200MΩ and 1 count on 1GΩ range at 6½ digits.

2-WIRE ACCURACY[7] ± (ppm of range)

RANGE	20 Ω	200 Ω	2 kΩ
ADDITIONAL UNCERTAINTY (inside T_{CAL} ± 5°C)	300 ppm	30 ppm	3 ppm
TEMPERATURE COEFFICIENT (outside T_{CAL} ± 5°C)	70ppm/°C	7ppm/°C	0.7ppm/°C

SPEED AND ACCURACY[9] 90 Days

RANGE	ACCURACY ± (ppm of reading+ppm of range+ppm of range rms noise[12]) 1 PLC DFILT Off	0.1 PLC[11] DFILT Off	0.01 PLC[8,11] DFILT Off
20 Ω	52+ 7+0.6	52+ 30+10	110+200+ 35
200 Ω	36+ 7+0.6	36+ 30+10	110+200+ 35
2 kΩ	33+ 4+0.2	33+ 24+ 1	130+230+ 5
20 kΩ	32+ 4+0.2	32+ 24+ 2	130+230+ 5
200 kΩ	72+ 4.5+0.5	72+ 25+ 4	150+300+ 10
2 MΩ[4]	110+ 4.5+ 2	110+ 25+15	150+300+150
20 MΩ[4]	560+ 4.5+ 5	560+ 30+20	560+300+150
200 MΩ[4]	10,000+100+ 40	10,000+120+80	10,000+700+250
1 GΩ[4]	20,000+100+ 40	20,000+120+80	20,000+700+250

PLC = Power Line Cycles. DFILT = Digital Filter.

SETTLING CHARACTERISTICS: For first reading following step change, add the total 90-day measurement error for the present range. Pre-programmed settling delay times are for <200pF external circuit capacitance. For 200MΩ and 1GΩ ranges, add total 1 year errors for first reading following step change. Reading settling times are affected by source impedance and cable dielectric absorption characteristics.

OHMS MEASUREMENT METHOD: Constant current.

OFFSET COMPENSATION: Available on 20Ω – 20kΩ ranges.

OHMS VOLTAGE DROP MEASUREMENT: Available as a multiple display.

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

OHMS (cont'd)

2-WIRE RESISTANCE READING RATES[10,12] 20Ω, 200Ω, 2kΩ, and 20kΩ Ranges

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND TO IEEE-488 Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	7½	6 (5.1)	2 (1.7)	5 (4)	2 (1.6)	5 (4)	2 (1.6)
2	33.4 ms (40 ms)	26	7½	30 (25)	8 (7.1)	28 (23)	8 (6.8)	27 (22)	8 (6.7)
1	16.7 ms (20 ms)	25	6½	58 (48)	40 (34)	53 (45)	37 (32)	49 (41)	35 (31)
0.2[11]	3.34 ms (4 ms)	22	6½	219 (189)	109 (97)	197 (162)	97 (87)	140 (129)	79 (74)
0.1[11]	1.67 ms (2 ms)	21	5½	300 (300)	126 (118)	248 (245)	112 (108)	164 (163)	89 (88)
0.02[11]	334 µs (400 µs)	19	5½	300 (300)	130 (130)	249 (249)	114 (114)	165 (165)	91 (91)
0.01[11]	167 µs (167 µs)	16	4½	421 (421)	135 (135)	306 (306)	114 (114)	189 (189)	92 (92)
0.01[8,11]	167 µs (167 µs)	16	4½	2000 (2000)		2000 (2000)			

2-WIRE RESISTANCE READING RATES[10,12] 20MΩ Range

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	7½	6 (5.1)	1 (0.8)	2 (1.8)	1 (0.8)
2	33.4 ms (40 ms)	26	7½	30 (25)	1 (0.8)	16(14.5)	1 (0.8)
1	16.7 ms (20 ms)	25	6½	58 (48)	4 (3.8)	25 (22)	4 (3.5)
0.1[11]	1.67 ms (2 ms)	21	5½	300 (296)	5 (5)	43 (39)	5 (4.7)
0.02[11]	334 µs (400 µs)	19	5½	300 (300)	5 (5)	43 (43)	5 (5)
0.01[11]	167 µs (167 µs)	16	4½	412 (412)	5 (5)	43 (43)	5 (5)

4-WIRE RESISTANCE READING RATES[10,12] Any Range

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS or READINGS WITH TIME STAMP/SECOND TO MEMORY or IEEE-488, AUTO ZERO ON Offset Comp. Off	Offset Comp. On
10	167 ms (200 ms)	28	7½	2 (1.6)	0.6 (0.5)
2	33.4 ms (40 ms)	26	7½	7 (6.1)	2 (1.6)
1	16.7 ms (20 ms)	25	6½	12 (11.6)	3 (3.7)
0.1[11]	1.67 ms (2 ms)	21	5½	20 (20)	6 (6)
0.01[11]	167 µs (167 µs)	16	4½	21 (21)	7 (7)

OHMS NOTES

1. Current source is typically ±9% absolute accuracy.
2. Total of measured value and lead resistance cannot exceed full scale.
3. Maximum offset compensation plus source current times measured resistance must be less than source current times resistance range selected.
4. For 2-wire mode.
5. Specifications are for 1 power line cycle, 10 reading digital filter, Auto Zero on, 4-wire mode, offset compensation on (for 20Ω to 20kΩ ranges).
6. For T_{CAL} ±1°C, following 55 minute warm-up. T_{CAL} is ambient temperature at calibration (23°C at the factory).
7. For T_{CAL} ±5°C, following 55-minute warm-up. Specifications include traceability to US NIST.
8. In burst mode, display off. Burst mode requires Auto Zero refresh (by changing resolution or measurement function) once every 24 hours.
9. For T_{CAL} ±5°C, 90-day accuracy. 1-year and 2-year accuracy can be found by applying the same speed accuracy ppm changes to the 1-year or 2-year base accuracy.
10. For DELAY=0, digital filter off, internal trigger, display off. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz). Speed for 200kΩ range is typically 10% slower than 20kΩ range; speed for 2MΩ range is typically 3 times faster than 20MΩ range; speed for 1GΩ range is typically 30%–50% as fast as 20MΩ range. See Operating Speed section for additional detail.
11. Ohms measurements at rates lower than 1 power line cycle are subject to potential noise pickup. Care must be taken to provide adequate shielding.
12. Typical values.
13. When measuring resistance of inductive loads, the inductance of that load must be 10mH or less.

DC AMPS

DCI INPUT CHARACTERISTICS AND ACCURACY[4]

RANGE	FULL SCALE	RESOLUTION	DEFAULT RESOLUTION	MAXIMUM BURDEN VOLTAGE[6]	ACCURACY[1] ± (ppm of reading + ppm of range) 24 Hours[2]	90 Days[3]	1 Year[3]	2 Years[3]	TEMPERATURE COEFFICIENT ± (ppm of reading + ppm of range)/°C Outside T_{CAL} ± 5°C
200 µA	210.00000	10 pA	100 pA	0.25 V	63 + 25	300 + 25	500 + 25	1350 + 25	58 + 7
2 mA	2.1000000	100 pA	1 nA	0.31 V	64 + 20	300 + 20	400 + 20	750 + 20	58 + 5
20 mA	21.000000	1 nA	10 nA	0.4 V	65 + 20	300 + 20	400 + 20	750 + 20	58 + 5
200 mA	210.00000	10 nA	100 nA	0.5 V	96 + 20	300 + 20	500 + 20	750 + 20	58 + 5
2 A	2.1000000	100 nA	1 µA	1.5 V	500 + 20	600 + 20	900 + 20	1350 + 20	58 + 5

DC CURRENT UNCERTAINTY = ±[(ppm reading)×(measured value) + (ppm of range)×(range used)] / 1,000,000.

% ACCURACY = (ppm accuracy) / 10,000.

10PPM OF RANGE = 20 counts at 6½ digits.

DCI READING RATES[5,9]

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND TO IEEE-488 Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	7½	6 (5.1)	2 (1.7)	6 (4.8)	2 (1.6)	6 (4.8)	2 (1.6)
2	33.4 ms (40 ms)	26	7½	30 (24)	10 (8.2)	28 (23)	9 (7.8)	27 (22)	9 (7.7)
1	16.7 ms (20 ms)	25	6½	57 (48)	45 (38)	53 (45)	41 (35)	48 (41)	40 (32)
0.2	3.34 ms (4 ms)	22	6½	217 (195)	122 (111)	186 (168)	109 (98)	135 (125)	88 (85)
0.1	1.67 ms (2 ms)	21	5½	279 (279)	144 (144)	234 (229)	123 (123)	158 (156)	99 (98)
0.02	334 µs (400 µs)	19	5½	279 (279)	148 (148)	234 (234)	130 (130)	158 (158)	101 (101)
0.01	167 µs (167 µs)	16	4½	298 (298)	150 (150)	245 (245)	132 (132)	164 (164)	102 (102)
0.01[7]	167 µs (167 µs)	16	4½	2000 (2000)		2000 (2000)			

DC AMPS (cont'd)

SPEED AND ACCURACY[8] 90 Days

RANGE	ACCURACY ± (ppm of reading + ppm of range + ppm of range rms noise[9]) 1 PLC DFILT Off	0.1 PLC DFILT Off	0.01 PLC[7] DFILT Off
200 µA	300+25+0.3	300+50+8	300+200+80
2 mA	300+20+0.3	300+45+8	300+200+80
20 mA	300+20+0.3	300+45+8	300+200+80
200 mA	300+20+0.3	300+45+8	300+200+80
2 A	600+20+0.3	600+45+8	600+200+80

PLC = Power Line Cycle. DFILT = Digital Filter.

SETTLING CHARACTERISTICS: <500µs to 50ppm of step size. Reading settling times are affected by source impedance and cable dielectric absorption characteristics. Add 50ppm of range for first reading after range change.

MAXIMUM ALLOWABLE INPUT: 2.1A, 250V.

OVERLOAD PROTECTION: 2A fuse (250V), accessible from front (for front input) and rear (for rear input).

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

DC AMPS NOTES

1. Specifications are for 1 power line cycle, Auto Zero on, 10 reading digital filter.
2. For T_{CAL} ± 1°C, following 55 minute warm-up.
3. For T_{CAL} ± 5°C, following 55 minute warm-up. Specifications include traceability to US NIST.
4. Add 50 ppm of range for current above 0.5A for self heating.
5. For DELAY=0, digital filter off, display off. Internal trigger. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz). See Operating Speed section for additional detail.
6. Actual maximum voltage burden = (maximum voltage burden) × ($I_{MEASURED}/I_{FULL\ SCALE}$).
7. In burst mode, display off. Burst mode requires Auto Zero refresh (by changing resolution or measurement function) once every 24 hours.
8. For T_{CAL} ±5°C, 90-day accuracy. 1-year and 2-year accuracy can be found by applying the same speed accuracy ppm changes to the 1-year or 2-year base accuracy.
9. Typical values.

DC IN-CIRCUIT CURRENT

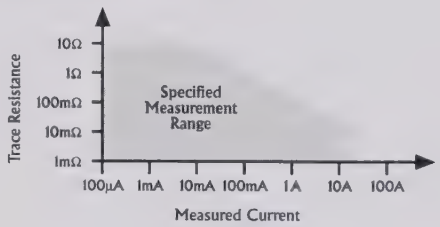
The DC in-circuit current measurement function allows a user to measure the current through a wire or a circuit board trace without breaking the circuit.

When the In-Circuit Current Measurement function is selected, the 2001 will first perform a 4-wire resistance measurement, then a voltage measurement, and will display the calculated current.

TYPICAL RANGES:

Current:	100µA to 12A.
Trace Resistance:	1mΩ to 10Ω typical.
Voltage:	±200mV max. across trace.
Speed:	4 measurements/second at 1 power line cycle.
Accuracy:	±(5% + 2 counts). For 1 power line cycle, Auto Zero on, 10 reading digital filter, T_{CAL} ±5°C, after being properly zeroed. 90 days, 1 year or 2 years.

MEASUREMENT RANGE CHART



AC AMPS

AC magnitude: RMS or Average.

ACI INPUT CHARACTERISTICS

RMS RANGE	PEAK INPUT	FULL SCALE RMS	RESOLUTION	DEFAULT RESOLUTION	MAXIMUM BURDEN VOLTAGE[5]	TEMPERATURE COEFFICIENT ± (% of reading + % of range)/°C Outside T_{CAL} ± 5°C
200 µA	1 mA	210.0000	100 pA	1 nA	0.25 V	0.01 + 0.001
2 mA	10 mA	2.100000	1 nA	10 nA	0.31 V	0.01 + 0.001
20 mA	100 mA	21.00000	10 nA	100 nA	0.4 V	0.01 + 0.001
200 mA	1 A	210.0000	100 nA	1 µA	0.5 V	0.01 + 0.001
2 A	2 A	2.100000	1 µA	10 µA	1.5 V	0.01 + 0.001

ACI ACCURACY[1,2] 90 Days, 1 Year or 2 Years, T_{CAL} ± 5°C, for 5% to 100% of range, ± (% of reading + % of range)

RANGE	20Hz–50Hz	50Hz–200Hz	200Hz–1kHz	1kHz–10kHz	10kHz–30kHz[3]	30kHz–50kHz[3]	50kHz–100kHz[3]
200 µA	0.35 + 0.015	0.2 + 0.015	0.4 + 0.015	0.5 + 0.015			
2 mA	0.3 + 0.015	0.15 + 0.015	0.12 + 0.015	0.12 + 0.015	0.25 + 0.015	0.3 + 0.015	0.5 + 0.015
20 mA	0.3 + 0.015	0.15 + 0.015	0.12 + 0.015	0.12 + 0.015	0.25 + 0.015	0.3 + 0.015	0.5 + 0.015
200 mA	0.3 + 0.015	0.15 + 0.015	0.12 + 0.015	0.15 + 0.015	0.5 + 0.015	1 + 0.015	3 + 0.015
2 A	0.35 + 0.015	0.2 + 0.015	0.3 + 0.015	0.45 + 0.015	1.5 + 0.015	4 + 0.015	

AC CURRENT UNCERTAINTY = ±[(% of reading) × (measured value) + (% of range) × (range used)] / 100.

PPM ACCURACY = (% accuracy) × 10,000.

0.015% OF RANGE = 30 counts at 5½ digits.

AC COUPLING: For AC only coupling, add the following % of reading:

	20–50Hz	50–100Hz	100–200Hz
rms, Average	0.55	0.09	0.015

AC+DC COUPLING: For DC>20% of AC rms voltage, apply the following additional uncertainty, multiplied by the ratio (DC/AC rms).

	% of Reading	% of Range
rms, Average	0.05	0.1

AC AMPS (cont'd)

ACI READING RATES[3,4]

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY Auto Zero Off	Auto Zero On	READINGS/SECOND TO IEEE-488 Auto Zero Off	Auto Zero On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	Auto Zero On
10	167 ms (200 ms)	28	6½	6 (5.1)	2 (1.7)	6 (4.9)	2 (1.6)	6 (4.8)	2 (1.6)
2	33.4 ms (40 ms)	26	5½	30 (25)	9 (7.9)	28 (23)	9 (7.6)	27 (22)	9 (7.5)
1	16.7 ms (20 ms)	25	5½	57 (48)	39 (35)	53 (45)	37 (33)	49 (41)	34 (30)
0.1	1.67 ms (2 ms)	21	5½	157 (136)	70 (70)	123 (123)	62 (62)	107 (107)	56 (53)
0.01	167 µs (167 µs)	16	4½	156 (136)	70 (70)	140 (140)	63 (63)	113 (113)	56 (56)
0.01[6]	167 µs (167 µs)	16	4½	2000 (2000)		2000 (2000)			

SETTLING CHARACTERISTICS: <300ms to 1% of step change
<450ms to 0.1% of step change
<500ms to 0.01% of step change

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

HIGH CREST FACTOR ADDITIONAL ERROR ± (% of reading)

Applies to rms measurements.

CREST FACTOR	1 – 2	2 – 3	3 – 4	4 – 5
ADDITIONAL ERROR	0	0.1	0.2	0.4

AVERAGE ACI MEASUREMENT

Rms specifications apply for 10% to 100% of range.

AC AMPS NOTES

1. Specifications apply for sinewave input, AC+DC coupling, 1 power line cycle, digital filter off, following 55 minute warm-up.
2. Add 0.005% of range uncertainty for current above 0.5A rms for self-heating.
3. Typical values.
4. For DELAY=0, digital filter off, display off, internal trigger. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz).
5. Actual maximum voltage burden = (maximum voltage burden) × (IMEASURED/IFULL SCALE).
6. In burst mode, display off. Burst mode requires Auto Zero refresh (by changing resolution or measurement function) once every 24 hours.

FREQUENCY COUNTER

FREQUENCY/PERIOD INPUT CHARACTERISTICS AND ACCURACY 90 Days, 1 Year, or 2 Years

	FREQUENCY RANGE[1]	PERIOD RANGE	DEFAULT RESOLUTION	MINIMUM SIGNAL LEVEL 1Hz–1MHz	1–5MHz	5–15MHz	MAXIMUM INPUT	TRIGGER LEVEL	ACCURACY ± (% of reading)
AC Voltage Input	1Hz–15 MHz	67 ns – 1 s	5 digits	60 mV	60 mV	350 mV	1100 V pk[1]	0–600V	0.03
AC Current Input	1Hz– 1 MHz	1 µs – 1 s	5 digits	150 µA			1 A pk	0–600mA	0.03

MEASUREMENT TECHNIQUE: Unique pulse count/time count at overflow.

TIME BASE: 7.68MHz ± 0.01%, 0°C to 55°C.

READING TIME: 420ms maximum.

TRIGGER LEVEL ADJUSTMENT: Trigger level is adjustable in 0.5% of range steps to ±60% of range in real-time using the up and down range buttons.

FREQUENCY RANGING: Autoranging from Hz to MHz.

FREQUENCY COUPLING: AC + DC or AC only.

FREQUENCY NOTES

1. Subject to 2 × 10⁷V•Hz product (for inputs above 20V).

TEMPERATURE (RTD)

RANGE	RESOLUTION	4-WIRE ACCURACY[3] 1 Hour[2]	90 Days	1 Year	2 Years
–100° to +100°C	0.001°C	±0.005°C	±0.05°C	±0.08°C	±0.12°C
–200° to +630°C	0.001°C	±0.005°C	±0.12°C	±0.14°C	±0.18°C
–212° to +180°F	0.001°F	±0.009°F	±0.09°F	±0.15°F	±0.22°F
–360° to +1102°F	0.001°F	±0.009°F	±0.15°F	±0.18°F	±0.33°F

RTD TYPE: 100Ω platinum; DIN 43 760 or IPTS-68, alpha 0.00385, 0.00390, 0.003916, or 0.00392, 4-wire.

MAXIMUM LEAD RESISTANCE (each lead): 12Ω (to achieve rated accuracy).

SENSOR CURRENT: 1mA (pulsed).

COMMON MODE REJECTION: <0.005°C/V at DC, 50Hz, 60Hz and 400Hz, (100Ω imbalance, LO driven).

TEMPERATURE COEFFICIENT: ±(0.0013% + 0.005°C)/°C or ±(0.0013% + 0.01°F)/°C outside TCAL ±5°C.

RTD TEMPERATURE READING RATES[1] (2- or 4-Wire)

NPLC	READINGS or READINGS WITH TIME STAMP/SECOND TO MEMORY or IEEE-488 Auto Zero Off	Auto Zero On
10	1 (1)	1 (1)
2	5 (4.3)	4 (3.6)
1	7 (6.5)	6 (5.5)
0.1	12 (10.8)	9 (9)
0.01	12 (12)	10 (10)

TEMPERATURE (Thermocouple)

THERMOCOUPLE TYPE	RANGE	DEFAULT RESOLUTION	ACCURACY[4]
J	–200° to + 760°C	0.1°C	±0.5°C
K	–200° to +1372°C	0.1°C	±0.5°C
T	–200° to + 400°C	0.1°C	±0.5°C
E	–200° to +1000°C	0.1°C	±0.6°C
R	0° to +1768°C	1 °C	±3 °C
S	0° to +1768°C	1 °C	±3 °C
B	+350° to +1820°C	1 °C	±5 °C

TC TEMPERATURE READING RATES[1]

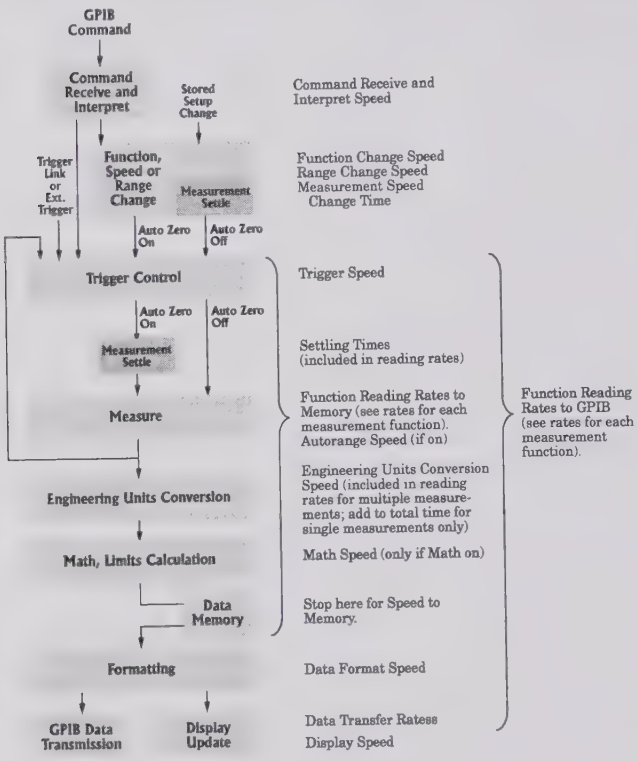
NPLC	READINGS/SECOND TO MEMORY Auto Zero Off	On	READINGS/SECOND TO IEEE-488 Auto Zero Off	On	READINGS/SECOND WITH TIME STAMP TO IEEE-488 Auto Zero Off	On
10	6 (5.1)	2 (1.7)	4 (3.4)	2 (1.4)	4 (3.4)	2 (1.4)
2	30 (25)	9 (7.6)	28 (23)	9 (7.3)	27 (22)	8 (7.2)
1	57 (48)	43 (37)	53 (45)	40 (32)	49 (41)	37 (30)
0.1	139 (139)	95 (95)	126 (123)	85 (84)	99 (99)	72 (72)
0.01	177 (177)	98 (98)	156 (156)	87 (87)	119 (119)	73 (73)

TEMPERATURE NOTES

1. Typical speeds for Auto Zero on. For DELAY=0, digital filter off, display off, internal trigger. Rates are for 60Hz and (50Hz).
2. For ambient temperature ±1°C, measured temperature ±10°C, 10-reading digital filter.
3. Excluding probe errors. TCAL ±5°C.
4. Relative to external 0°C reference junction; exclusive of thermocouple errors. Junction temperature may be external. Applies for 90 days, 1 year or 2 years, TCAL ±5°C.

OPERATING SPEED

The following diagram illustrates the factors that determine a DMM's reading rate.


GPIB Command
Command Receive and Interpret
Stored Setup Change
Command Receive and Interpret Speed
Trigger Link or Ext. Trigger
Function, Speed or Range Change
Measurement Settle
Function Change Speed
Range Change Speed
Measurement Speed
Change Time
Auto Zero On
Auto Zero Off
Trigger Control
Trigger Speed
Auto Zero On
Auto Zero Off
Measurement Settle
Settling Times (included in reading rates)
Measure
Function Reading Rates to Memory (see rates for each measurement function). Autorange Speed (if on)
Function Reading Rates to GPIB (see rates for each measurement function).
Engineering Units Conversion
Engineering Units Conversion Speed (included in reading rates for multiple measurements; add to total time for single measurements only)
Math, Limits Calculation
Math Speed (only if Math on)
Data Memory
Stop here for Speed to Memory.
Formatting
Data Format Speed
GPIB Data Transmission
Display Update
Data Transfer Rates
Display Speed

COMMAND RECEIVE AND INTERPRET SPEED

	FASTEST	TYPICAL	SLOWEST
Time per character	0.16 ms	0.28 ms	0.66 ms
Characters per second	6250	3751	1515

TYPICAL COMMAND TIMES Command	Receive and Interpret Time	Rate (per second)
SENSE1:VOLTAGE:AC: RESOLUTION MAXIMUM	9.4 ms	106
VOLT:AC:RES:MAX	4.1 ms	243
SENSE1:FUNC 'VOLT:AC"	6.3 ms	158
RESISTANCE:RANGE:UPPER 1E9	9.0 ms	111
STATUS:QUEUE:CLEAR	5.1 ms	196
STAT:QUE:CLE	3.1 ms	322
*TRG	1.2 ms	833

MEASUREMENT SPEED CHANGE TIMES[1,2]

Typical delay before first reading after making a speed change.

FUNCTION	From	To	AUTO ZERO OFF Time	AUTO ZERO ON Time
DCV, DCI, ACI	Any	≤ 0.1 PLC	66 ms	44 ms
	Any	1 PLC	190 ms	140 ms
	Any	10 PLC	1540 ms	1195 ms
ACV	Any	≤ 0.1 PLC	120 ms	100 ms
	Any	1 PLC	250 ms	197 ms
	Any	10 PLC	1600 ms	1250 ms
Ohms (2-wire)	Any	≤ 0.1 PLC	69 ms	57 ms
	Any	1 PLC	195 ms	170 ms
	Any	10 PLC	1540 ms	1370 ms
Ohms (4-wire)	Any	≤ 0.1 PLC	110 ms	46 ms
	Any	1 PLC	240 ms	165 ms
	Any	10 PLC	1590 ms	1370 ms
TC Temperature	Any	≤ 0.1 PLC	80 ms	55 ms
	Any	1 PLC	195 ms	170 ms
	Any	10 PLC	1545 ms	1370 ms

FUNCTION CHANGE SPEED[1]

FROM Function	TO Function	Range(s)	AUTO ZERO OFF TIME	AUTO ZERO OFF RATE (per second)	AUTO ZERO ON TIME	AUTO ZERO ON RATE (per second)
Any	DCV	200mV, 2V	8.1 ms	120	36 ms	27
		20V	8.1 ms	120	8.6 ms	110
		200V	24 ms	40	52 ms	19
		1000V	11 ms	160	10.2 ms	190
Any	ACV	Any	563 ms	1.8	563 ms	1.8
Any except ACI	DCI	200µA, 2mA, 20mA	4.5 ms	220	5.1 ms	190
		200mA, 2A	6.0 ms	160	6.6 ms	150
ACI		Any	21.1 ms	45	22 ms	45
Any	ACI	Any	521 ms	1.9	521 ms	1.9
Any	Ohms (2-wire)	20Ω, 200Ω, 2kΩ, 20kΩ	6.0 ms	165	34 ms	29
		200kΩ	26 ms	38	61 ms	16
		2MΩ	95 ms	10.5	425 ms	2.4
		20MΩ	265 ms	4	690 ms	1.4
		200MΩ, 1GΩ	366 ms	3	5.5 ms	180
Any	Ohms (4-wire)	20Ω, 200Ω, 2kΩ, 20kΩ	12 ms	140	34.1 ms	29
		200kΩ	26 ms	38	60 ms	16
Any except ACI and Ohms	Frequency[6]	Any	61 ms	16	60 ms	17
ACI, Ohms (4-wire)		Any	79 ms	12	75 ms	13
Ohms (2-wire)		Any	418 ms	2	416 ms	2
Any	RTD Temp. (2-wire)	Any	6.0 ms	165	33 ms	30
	RTD Temp. (4-wire)	Any	11.5 ms	150	37 ms	27
	TC Temp.	Any	8.0 ms	125	35 ms	28

OPERATING SPEED (cont'd)

RANGE CHANGE SPEED[1]

FUNCTION	From	To	AUTO ZERO OFF TIME	AUTO ZERO OFF RATE (per second)	AUTO ZERO ON TIME	AUTO ZERO ON RATE (per second)
DCV	200mV, 2V	20V	4.5 ms	220	3.1 ms	190
	200V, 1000V	20V	8.0 ms	120	8.6 ms	110
	200mV, 2V, 20V	200mV, 2V, 20V	4.5 ms	220	36 ms	27
	200V, 1000V	200mV, 2V	8.0 ms	120	38 ms	26
	200mV, 2V, 20V	200V	24 ms	41	52 ms	19
	1000V	200V	9 ms	110	37 ms	27
	Any	1000V	11 ms	165	10.1 ms	190
ACV	Any	Any	563 ms	1.8	563 ms	1.8
DCI	Any	200µA, 2mA, 20mA	4.5 ms	220	5.2 ms	190
		200mA, 2A	6.0 ms	160	6.6 ms	150
ACI	Any	Any	525 ms	1.9	525 ms	1.9
Ohms (2-wire)	Any	20Ω, 200Ω, 2kΩ, 20kΩ	6.0 ms	160	34 ms	29
	Any	200kΩ	26 ms	38	66 ms	15
	Any	2MΩ	95 ms	10	420 ms	2.3
	Any	20MΩ	265 ms	3.7	690 ms	1.4
	Any	200MΩ, 1GΩ	366 ms	2.7	5.5 ms	180
Ohms (4-wire)	Any	20Ω, 200Ω, 2kΩ, 20kΩ	8 ms	160	34 ms	29
	Any	200kΩ	26 ms	38	66 ms	16

TRIGGER SPEED (External Trigger or Trigger-Link)

	Auto Zero On	Auto Zero Off
Trigger Latency:	1.2 ms typical	2 µs
Trigger Jitter:		±0.5 µs

ENGINEERING UNIT CONVERSION SPEED

Included in reading times for multiple measurements; add to total time for single measurements only.

CONFIGURATION	TIME	RATE (per second)
DCV	2.4 ms	416
DCV, Filter on	2.4 ms	416
DCV, Relative on	2.5 ms	400
DCV, Ratio on	3.7 ms	270
ACV	5.3 ms	188
ACV, Relative on	5.3 ms	188
ACV, Filter on	6.8 ms	147
ACV, dB	9.4 ms	106
ACV, dBm	17.3 ms	57

DISPLAY SPEED

Display updated at up to 20 times per second. Display update can be suspended by holding the display (press ENTER) or setting Display Enable Off from GPIB.

MATH AND LIMITS CALCULATION SPEED[1]

CALCULATION	NOMINAL TIME	NOMINAL RATE (per second)	MAXIMUM TIME
mX + b	0.35 ms	2850	0.44 ms
Percent	0.60 ms	1660	0.64 ms
Limits[6]	0.35 ms	2850	0.37 ms
None	0.07 ms		0.08 ms

GPIB DATA FORMATTING TRANSMISSION TIME[3]

FORMAT	READINGS ONLY Time	READINGS ONLY Rdg./s	READINGS WITH TIME STAMP Time	READINGS WITH TIME STAMP Rdg./s
DREAL (Double precision real)	0.30 ms	3330	2.0 ms	500
SREAL (Single precision real)	0.37 ms	2710	2.1 ms	475
ASCII	3.9 ms	255	8.2 ms	120

SINGLE FUNCTION SCAN SPEED[4] (Internal Scanner)

TYPE	DCV (20V)[7] Time per Chan.	DCV (20V)[7] Rate (Chan./second)	2-Wire Ohms (2kΩ)[7] Time per Chan.	2-Wire Ohms (2kΩ)[7] Rate (Chan./second)	4-Wire Ohms (2kΩ)[7] Time per Chan.	4-Wire Ohms (2kΩ)[7] Rate (Chan./second)	ACV Time per Chan.	ACV Rate (Chan./second)	Frequency Time per Chan.	Frequency Rate (Chan./second)	TC Temperature Time per Chan.	TC Temperature Rate (Chan./second)	RTD Temperature (2-Wire) Time per Chan.	RTD Temperature (2-Wire) Rate (Chan./second)
Ratio or Delta[5] (2 channels)	4 ms	250	4.4 ms	230	18.5 ms	54								
Fast Scan (using solid state channels)	5.5 ms	181	7 ms	140			520 ms	1.9	958 ms	1	13.8 ms	72		
Normal Scan	10.3 ms	97	12.1 ms	80	21 ms	47	532 ms	1.8	974 ms	1	18 ms	55	95 ms	10

MIXED FUNCTION SCAN SPEED[1] (Internal Scanner)

SCAN CONFIGURATION (Channels)	Average Time/Channel	Average Rate (Channel/s)
5 chan. DCV, 5 chan. 2wΩ	20 ms	50
3 DCV, 3 2wΩ, 4 TC	22 ms	45
5 2wRTD, 5 TC	60 ms	17
5 2wΩ, 5 2wRTD	60 ms	17
9 DCV, 1 ACV	73 ms	13
2 DCV, 1 ACV, 2 2wΩ, 1 4wΩ	122 ms	8
5 DCV, 5 Freq.	490 ms	2
3 DCV, 3 ACV, 2 4wΩ	220 ms	5

OPERATING SPEED NOTES

1. With Display off, 1 power line cycle, autorange off, filter off, triggers halted. Display on may impact time by 3% worst case. To eliminate this impact press ENTER (hold) to lock out display from front panel.
2. Based on using 20V, 2kΩ, 200mA ranges.
3. Auto Zero off, using 386SX/16 computer, average time for 1000 readings, byte order swapped, front panel disabled.
4. Typical times for 0.01 power line cycle, autorange off, Delay=0, 100 measurements into buffer.
5. Ratio and delta functions output one value for each pair of measurements.
6. Time to measure, evaluate limits, and set digital outputs are found by summing measurement time with limits calculation time.
7. Auto Zero off.
8. Based on 100kHz input frequency.

DELAY AND TIMER

TIME STAMP

Resolution: 1µs.
Accuracy: ±0.01% ±1µs.
Maximum: 2,100,000.000 000 seconds (24 days, 20 hours).

DELAY TIME (Trigger edge to reading initiation)

Maximum: 999,999.999 seconds (11 days, 12 hours).
Resolution: 1ms.
Jitter: ±1ms.

TIMER (Reading initiation to reading initiation)

Maximum: 999,999.999 seconds (11 days, 12 hours).
Resolution: 1ms.
Jitter: ±1ms.

NOTE: To find measurement speed, see each measurement section.

MAXIMUM INPUT LEVELS

	RATED INPUT[1]	OVERLOAD RECOVERY TIME
HI to LO	±1100V pk	< 900 ms
HI Sense to LO	± 350V pk 250V rms	< 900 ms
LO Sense to LO	± 350V pk 250V rms	< 900 ms
I Input to LO	2A, ± 250V (fused)	—
HI to Earth	±1600V	< 900 ms
LO to Earth	± 500V	

1. For voltages between other terminals, these ratings can be algebraically added.

IEEE-488 BUS IMPLEMENTATION

IMPLEMENTATION: IEEE-488.2, SCPI-1991.0.
MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.
UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.
INTERFACE COMMANDS: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

DIGITAL I/O

CONNECTOR TYPE: 8 pin "D" subminiature.
INPUT: One pin, TTL compatible.
OUTPUTS: Four pins. Open collector, 30V maximum pull-up voltage, 100mA maximum sink current, 10Ω output impedance.
CONTROL: Direct control by output or set real-time with limits.

GENERAL SPECIFICATIONS AND STANDARDS COMPLIANCE

POWER

Voltage: 90–134V and 180–250V, universal self-selecting.
Frequency: 50Hz, 60Hz, or 400Hz self-identifying.
Consumption: <55VA.

ENVIRONMENTAL

Operating Temperature: 0°C to 50 °C.
Storage Temperature: –40 °C to 70 °C.
Humidity: 80% R.H., 0°C to 35°C, per MIL-T-28800E[1] Para 4.5.5.1.2.

NORMAL CALIBRATION

Type: Software. No manual adjustments required.
Sources: 2 DC voltages (2V, 20V) and 2 resistances (19k and 1M). Different calibration source values are allowed. All other functions calibrated (adjusted) from these sources and a short circuit. No AC calibrator required for adjustment.

PHYSICAL

Case Dimensions: 90mm high × 214mm wide × 369mm deep (3½ in. × 8½ in. × 14½ in.).
Working Dimensions: From front of case to rear including power cord and IEEE-488 connector: 15.0 inches.
Net Weight: <4.2kg (<9.2 lbs.).
Shipping Weight: <9.1kg (<20lbs.).

STANDARDS

EMI/RFI: Conforms to VDE 0871B (per Vfg 1046/1984), IEC 801-2. Meets FCC part 15 Class B, CISPR-22 (EN55022).
Safety: Conforms to IEC348, CAN/CSA-C22.2. No. 231, MIL-T-28800E[1]. Designed to UL1244.
Reliability: MIL-T-28800E[1].
Maintainability: MIL-T-28800E[1].
MTTR: <90 minutes (includes disassembly and assembly, excludes recalibration). MTTR is Mean Time To Repair.
MTBF, Estimated: >75,000 hours (Bellcore method). MTBF is Mean Time Between Failure.
MTTC: <20 minutes for normal calibration. <6 minutes for AC self-calibration. MTTC is Mean Time To Calibrate.
Process: MIL-STD 45662A and BS5750.

ACCESSORIES SUPPLIED

The unit is shipped with line cord, high performance modular test leads, user's manual, option slot cover, and full calibration data. A personal computer startup package is available free.

Note 1: For MIL-T-28800E, applies to Type III, Class 5, Style E.

EXTENDED MEMORY / NON-VOLATILE MEMORY OPTIONS

MODEL	SIZE (Bytes)	DATA STORAGE 4½-Digit	DATA STORAGE 6½-Digit w/Time Stamp	DATA STORAGE Type	SETUP STORAGE Number	SETUP STORAGE Type
2001	8k	2,027	404	volatile	1	non-volatile
2001/MEM1	32k	6,909	1,381	non-volatile	5	non-volatile
2001/MEM2	128k	29,908	5,980	non-volatile	10	non-volatile

These are the minimum sizes to expect.

B

Default Conditions

NOTE: All commands affected by *RST and :SYSTem:PRESet can be saved by the *SAV command.

Command	*RST	:SYSTem:PRESet
IEEE 488.2 common commands		
All commands	[unaffected]	[unaffected]
SCPI signal oriented commands		
:CONFigure	"VOLT:DC"	"VOLT:DC"
Calculate 1 subsystem		
:CALCulate1		
:STATe	0 (OFF)	0 (OFF)
:FORMat	PERCent	PERCent
:MMFactor	1.0	1.0
:MBFactor	0.0	0.0
:PERCent	1.0	1.0
Calculate 2 subsystem		
:CALCulate2		
:STATe	0 (OFF)	0 (OFF)
:FORMat	NONE	NONE
Calculate 3 subsystem		
:CALculate3		
:LIM1		
:STATe	0 (OFF)	0 (OFF)
:UPPer		
:DATA	1.0	1.0
:SOURce	0	0
:LOWer		
:DATA	-1.0	-1.0
:SOURce	0	0
:CLEar		
:AUTO	1 (ON)	1 (ON)

Command	*RST	:SYSTem:PRESet
:CALculate3		
:LIM2		
:STATe	0 (OFF)	0 (OFF)
:UPPer		
:DATA	1.0	1.0
:SOURce	0	0
:LOWer		
:DATA	-1.0	-1.0
:SOURce	0	0
:CLear		
:AUTO	1 (ON)	1 (ON)
:BSTRobe		
:STATe	0 (OFF)	0 (OFF)
:PASS		
:SOURce	0	0
Calibration subsystem		
All commands	[unaffected]	[unaffected]
Display subsystem		
:DISPlay		
:SMESsage	0 (OFF)	0 (OFF)
:WINDow1		
:TEXT		
:STATe	[unaffected]	[unaffected]
:DATA	[unaffected]	[unaffected]
:WINDow2		
:TEXT		
:STATe	[unaffected]	[unaffected]
:DATA	[unaffected]	[unaffected]
:ENABle	[unaffected]	[unaffected]
Format subsystem		
:FORMat		
:DATA	ASCII	ASCII
:BORDer	SWAPped	SWAPped
:ELEMents	READing	all
Output subsystem		
All commands	[unaffected]	[unaffected]
Route subsystem		
:ROUTe		
:CLOSe	[unaffected]	[unaffected]
:OPEN	[unaffected]	[unaffected]
:SCAN		
:INTernal	empty	empty
:FUNCtion	all "VOLT:DC"	all "VOLT:DC"
:EXTernal	empty	empty
:FUNCtion	all "VOLT:DC"	all "VOLT:DC"

Command	*RST	:SYSTem:PRESet
:ROUTE		
:SCAN		
:RATio		
:RCHannel	5	5
:MCHannel	10	10
:FUNCtion	"VOLT:DC"	"VOLT:DC"
:DELTa		
:RCHannel	5	5
:MCHannel	10	10
:FUNCtion	"VOLT:DC"	"VOLT:DC"
:LSELect	NONE	NONE
Sense commands		
:SENSe1		
:FUNCtion	"VOLT:DC"	"VOLT:DC"
AC current commands		
:SENSe1		
:CURRent		
:AC		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:COUPling	AC	AC
:RANGe		
:UPPer	2.1	2.1
:AUTO	1 (ON)	1 (ON)
:ULIMit	2.1	2.1
:LLIMit	2.0E-4	2.0E-4
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	6	6
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	0 (OFF)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	5	5
:DETector		
:FUNCtion	RMS	RMS
DC current commands		
:SENSe1		
:CURRent		
:DC		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)

Command	*RST	:SYSTem:PRESet
:SENSe1		
:CURRent		
:DC		
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:RANGe		
:UPPer	2.1	2.1
:AUTO	1 (ON)	1 (ON)
:ULIMit	2.1	2.1
:LLIMit	2.0E-4	2.0E-4
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOV
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	1	1
:METHod	NORMal	NORMal
AC voltage commands		
:SENSe1		
:VOLTage		
:AC		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:COUPling	AC	AC
:RANGe		
:UPPer	775	775
:AUTO	1 (ON)	1 (ON)
:ULIMit	775	775
:LIMit	.2	.2
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:REFerence?		
:DIGits	6	6
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	0 (OFF)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	5	5
:DETector	RMS	RMS
:FUNCtion	0.1	0.1

Command	*RST	:SYSTem:PRESet
DC voltage commands		
:SENSe1:		
:VOLTage		
:DC		
:APERture	1/LineFreq	1/LineFreq
:NPLCycle	1	1
:AUTO	0 (OFF	0 (OFF
:RANGe		
:UPPer	1100	1100
:AUTO	1 (ON)	1 (ON)
:ULIMit	1100	1100
:LLIMit	.2	.2
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	0 (OFF)
:NTOLerance	1	1
Frequency commands		
:SENSe1		
:FREQuency		
:COUPling	AC	AC
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	5	5
:THReshold		
:VOLTage		
:LEVel	0	0
:RANGe	10	10
:CURRent		
:LEVel	0	0
:RANGe	1.0E-3	1.0E-3
:SOURce	VOLTage	VOLTage
2-wire resistance commands		
:SENSe1		
:RESistance		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)

Command	*RST	:SYSTem:PRESet
:SENSe1		
:RESistance		
:RANGe		
:UPPer	1.1E+9	1.1E+9
:AUTO	1 (ON)	1 (ON)
:ULIMit	1.1E+9	1.1E+9
:LLIMit	20	20
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:OCOMpensated	0 (OFF)	0 (OFF)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	1	1
4-wire resistance commands		
:SENSe1		
:FRESistance		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:RANGe		
:UPPer	2.1E+5	2.1E+5
:AUTO	1 (ON)	1 (ON)
:ULIMit	2.1E+5	2.1E+5
:LLIMit	20	20
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:OCOMpensated	0 (OFF)	0 (OFF)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	1	1
Temperature commands		
:SENSe1		
:TEMPerature		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)

Command	*RST	:SYSTem:PRESet
:SENSe1		
:TEMPerature		
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	6	6
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:RJUNction1		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction2		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C,	23(°C,
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction3		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction4		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction5		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:TRANsducer	FRTD	FRTD
:RTD		
:TYPE	PT385	PT385
:ALPHa	0.00385	0.00385
:BETA	0.111	0.111
:DELTa	1.507	1.507
:RZERo	100.0	100.0
:TCouple		
:TYPE	J	J

Command	*RST	:SYSTem:PRESet
Source subsystem		
All commands	[unaffected]	[unaffected]
System subsystem		
:SYSTem		
:KEY	[unaffected]	[unaffected]
:AZERo		
:STATe	1 (ON)	1 (ON)
:TYPE	NORMal	NORMal
:LSYNc		
:STATe	0 (OFF)	0 (OFF)
:POSetup	[unaffected]	[unaffected]
:AMEThod	NORMal	NORMal
:FETCh		
:FORMat	[unaffected]	[unaffected]
Trigger subsystem		
:INITiate		
:CONTinuous	0 (OFF)	1 (ON)
:ARM:SEQuence1		
:LAYer1		
:COUNt	1	1
:SOURce	IMMediate	IMMediate
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	2	2
:OLINe	1	1
:LAYer2		
:COUNt	1	INF
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.1	0.1
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	2	2
:OLINe	1	1
:TRIGger		
:SEQuence1		
:COUNt	1	INF
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.1	0.1
:TCONfigure		
:PROTcol	ASYNchronous	ASYNchronous
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	2	2
:OLINe	1	1
:SSYNchronous		
:LINE	1	1

Command	*RST	:SYSTem:PRESet
Status subsystem		
All commands	[unaffected]	[unaffected]
Trace subsystem		
All commands	[unaffected]	[unaffected]
Unit commands		
:UNIT		
:TEMPerature	C	C
:VOLTage		
:AC	V	V
:DB		
:REFerence	1	1
:DBM		
:IMPedance	75	75

C

IEEE-488.2 Common Commands

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers, and Error Queue.
*ESE <NRf>	Event Enable command	Sets the contents of the Standard Event Enable Register.
*ESE?	Event Enable query	Request the programmed value of the Standard Event Enable Register.
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII "1" into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Returns an ID code that indicates which memory option is installed and whether or not the optional scanner card is installed.
*RCL <NRf>	Recall command	Returns the Model 2001 to the setup configuration stored in the designated memory location.
*RST	Reset command	Returns the Model 2001 to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.
*SRE?	Service request enable query	The Model 2001 returns the value of the Service Request Enable Register.
*STB?	Read status byte query	Returns the value of the Status Byte Register.
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.
*TST?	Self-test query	When this query is sent, the Model 2001 will perform a checksum test on ROM and return the results.
*WAI	Wait-to-continue command	Wait until all previous commands are executed.

D

SCPI Command Subsystems

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

Table D-1
Calculate command summary

Command	Description
:CALCulate[1]	Subsystem to control CALC 1:
:FORMat <name>	Select math format: MXB, PERCent, NONE.
:FORMat?	Query math format.
:KMATh	Path to configure math calculations:
:MMFactor <NRf>	Specify "m" for mX+b (-9.99e35 to +9.99e20).
:MMFactor?	Query "m" factor.
:MBFactor <NRf>	Specify "b" for mX+b (-9.99e35 to +9.99e30).
:MBFactor?	Query "b" factor.
:PERCent <NRf>	Set PERCENT value (-2.0e9 to +2.0e9).
:PERCent?	Query PERCENT.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.
:STATe?	Query state of math function.
:DATA?	Read math result of CALC 1.
:IMMediate	Recalculate input data.
:CALCulate2	Subsystem to control CALC 2:
:FORMat <name>	Select math format: MEAN, SDEViation, MAXimum, MINimum, PKPK, NONE.
:FORMat?	Query math format.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.
:STATe?	Query state of math function.
:IMMediate	Recalculate raw input data in buffer.
:DATA?	Read math result of CALC 2.
:CALCulate3	Subsystem to control CALC 3 (limit tests):
:LIMit[1]	Path to control LIMIT 1 test:
:UPPer	Path to configure upper limit:
[:DATA] <n>	Specify upper limit (-9.99e35 to +9.99e35).
[:DATA]?	Query upper limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source.
:LOWer	Path to configure lower limit:
[:DATA] <n>	Specify lower limit (-9.99e35 to +9.99e35).
[:DATA]?	Query lower limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.
:STATe?	Query state of limit test.
:FAIL?	Query test result (1 = pass, 0 = fail).
:CLEAR	Path to clear failed test:
[:IMMediate]	Clear failed test indication.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.
:AUTO?	Query auto clear.
:LIMit2	Path to control LIMIT 2 test:
:UPPer	Path to configure upper limit:
[:DATA] <n>	Specify upper limit (-9.99e35 to +9.999999e35).
[:DATA]?	Query upper limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source (digital output value).
:LOWer	Path to configure lower limit:
[:DATA] <n>	Specify lower limit (-9.99e35 to +9.999999e35).
[:DATA]?	Query lower limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source (digital output value).

Table D-1 (cont.)
Calculate command summary

Command	Description
:CALCulate3	
:LIMit2	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.
:STATe?	Query state of limit test.
:FAIL?	Query test result (1=pass, 0=fail).
:CLEAR	Path to clear failed test:
[:IMMediate]	Clear failed test indication.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.
:AUTO?	Query auto clear.
:PASS	Path to define "pass" digital output pattern.
:SOURce <NRf>	Specify digital output (0 to 15).
:CLIMits	Command path for composite limits:
:FAIL?	Query composite result of LIMIT 1 and LIMIT 2 tests (1=pass, 0=fail).
:BSTRobe	Path to control limit binning strobe:
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) strobe.
:STATe?	Query state of binning strobe.
:IMMediate	Re-perform limit tests.

Table D-2
CALibrate command summary

Command	Description
:CALibration	Calibration root command.
:PROTected	All commands in this subsystem are protected by the CAL switch.
:LOCK	Lock out calibration (opposite of enabling cal with CAL switch).
:SWITch?	Request comprehensive CAL switch state. (0=locked; 1=unlocked)
:SAVE	Save cal constants to EEPROM.
:DATA?	Download cal constants from 2001.
:DATE "<string>"	Send cal date to 2001.
:DATE?	Request cal date from 2001.
:NDUE "<string>"	Send next due cal date to 2001.
:NDUE?	Request next due cal date from 2001.
:LLEVel	Low-level calibration subsystem.
:SWITch?	Request low-level CAL switch state. (0=locked; 1=unlocked)
:STEP <Step #>	
1	20V AC at 1kHz step.
2	20V AC at 30kHz step.
3	200V AC at 1kHz step.
4	200V AC at 30kHz step.
5	1.5V AC at 1kHz step.
6	0.2V AC at 1kHz step.
7	5mV AC at 100kHz step.
8	0.5mV AC at 1kHz step.
9	+2V DC step.
10	-2V DC step.
11	0V DC step.
12	20mA AC at 1kHz step.
13	+0.2A DC step.
14	+2A DC step.
15	2V AC at 1Hz step.

Table D-2 (cont.)
CALibrate command summary

Command	Description
:CALibration	
:PROTected	
:LLEVel	
:STEP?	Request the current calibration step.
:CALCulate	Calculate low-level cal constants.
:DC	User calibration subsystem.
:ZERO	Low-thermal short calibration step.
:LOW <NRf>	+2V DC calibration step.
:HIGH <NRf>	+20V DC calibration step.
:LOHM <NRf>	20kΩ calibration step.
:HOHM <NRf>	1MΩ calibration step.
:OPEN	Open circuit calibration step.
:CALCulate	Calculate DC cal constants
:UNPRotected	All commands in this subsystem are not protected by CAL switch.
:ACCompensation	Perform user AC calibration (disconnect all cables).

Table D-3
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages
:DATA <a>	Define ASCII message "a" using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:DATA?	Query data on top portion of display.
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:DATA?	Query data on bottom portion of display.
:CNDisplay	Clear NEXT (or PREV) display messages and cancels associated operations.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display.
:ENABle?	Query state of the display (0 or 1).

Table D-4
FORMat command summary

Command	Description
:FORMat	
[:DATA] <type>[,<length>]	Select data format: ASCii, REAL, 32, REAL, 64, SREal or DREal.
[:DATA]?	Query data format.
:ELEMents <item list>	Specify data elements: READing, CHANnel, RNUMber, UNITs, TIMEstamp and STATus.
:ELEMents?	Query data elements.
:BORDer <name>	Select binary byte order: NORMal, SWAPped.
:BORDer?	Query byte order.

Table D-5
OUTPut command summary

Command	Description
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 4.

Table D-6
ROUTe command summary

Command	Description
:ROUTe	
:CLOSe <list>	Path and command to close specified channel:
:STATe?	Query closed channel.
:CLOSe? <list>	Query specified channels (1 = closed, 0 = open).
:OPEN <list>	Open specified channel or all channels.
:OPEN:ALL	Open all channels.
:OPEN? <list>	Query specified channels (1 = open, 0 = closed).
:SCAN	Command path to configure and control scan operations:
[:INTernal] <list>	Specify an internal scan list (2 to 10 channels).
[:INTernal]?	Query the internal scan list.
:FUNCtion <list>, <name>	Assign measurement function to specified channels.
:FUNCtion? <list>	Query function for each specified channel.
:EXTernal <list>	Specify an external scan list (2 to 80 channels).
:EXTernal?	Query the external scan list.
:FUNCtion <list>, <name>	Assign measurement function to specified channels.
:FUNCtion? <list>	Query function for each specified channel.

Table D-6 (cont.)
ROUTe command summary

Command	Description
:ROUTe	
:SCAN	
:RATio	Command path to configure ratio calculation:
:FUNCtion <name>	Specify function for Ratio ('VOLTage:DC', 'RESistance' or "FRESistance').
:FUNCtion?	Query Ratio function.
:RCHannel <list>	Specify reference channel (1 to 10).
:RCHannel?	Query reference channel.
:MCHannel <list>	Specify measure channel (1 to 10).
:MCHannel?	Query measure channel.
:DELTa	Command path to configure delta calculation:
:FUNCtion <name>	Specify function for Delta ('VOLTage:DC', 'RESistance' or "FRESistance').
:FUNCtion?	Query Delta function.
:RCHannel <list>	Specify reference channel (1 to 10).
:RCHannel?	Query reference channel.
:MCHannel <list>	Specify measure channel (1 to 10).
:MCHannel?	Query measure channel.
:LSELect <name>	Select scan operation: INTernal, EXTernal, RATio, DELTa, NONE.
:LSELect?	Query scan operation.

Table D-7
SENSe command summary

Command	Description
[:SENSe[1]]	
:ALTernate[1]	Path to control an Alternate setup.
:SAVE	Save current setup as Alternate setup.
:RECall	Return instrument to Alternate setup.
:FUNCtion <name>	Select measurement function: 'VOLTage:AC', 'VOLTage:DC', 'RESistance','FRESistance', 'CURRent:AC', 'CURRent:DC', 'FREQuency', 'TEMPerature'
:FUNCtion?	Query function.
DATA	Path to select reading type:
[:LATest]?	Query the latest reading.
:FRESh?	Query a fresh reading.
:CURRent:AC	Path to configure AC current.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +2.1).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.

Table D-7 (cont.)
SENSe command summary

Command	Description
[:SENSe[1]]	
:CURRent:AC	
:RANGe	
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +2.1).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +2.1).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or oFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:DETector	Path to select function:
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage.
[:FUNCtion]?	Query detector function.
:CURRent:DC	Path to configure DC current.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 2.1).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.

Table D-7 (cont.)
SENSe command summary

Command	Description
[:SENSe[1]]	
:CURRent:DC	
:RANGe	
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:METHod <name>	Select measurement technique: NORMal, ICIRcuit.
:METHod?	Query method.
:VOLTage:AC	Path to configure AC voltage.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.

Table D-7 (cont.)
SENSe command summary

Command	Description
:VOLTage:AC	
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +775).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +775).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +775).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-775 to +775).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:DETector	Path to select function:
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage, PEAK, LFRMs, NPeak, PPeak.
[:FUNCtion]?	Query detector function.
:PWINdow <n>	Specify window in seconds (0.1 to 9.9).
:PWINdow?	Query peak spike detection window.
:VOLTage:DC	Path to configure DC voltage:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate number of line cycles; (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.

Table D-7 (cont.)
SENSe command summary

Command	Description
:VOLTage:DC	
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 1100).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 1100).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 1100).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-1100 to +1100).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:RESistance	Path to configure resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or oN) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 1.05e9).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.

Table D-7 (cont.)
SENSe command summary

Command	Description
:RESistance	
:RANGe	
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 1.05e9).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for autorange (0 to 1.05e9).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-1.05e9 to +1.05e9).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value).
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select the filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.
:OCOMpensated?	Query Offset Compensation.
:FRESistance	Path to configure four-wire resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 2.1e5).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or OJ) or disable (0 or OFF) auto range.

Table D-7 (cont.)
SENSe command summary

Command	Description
:FRESistance	
:RANGe	
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1e5).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for autorange (0 to 2.1e5).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1e5 to +2.1e5).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value).
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select the filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.
:OCOMpensated?	Query Offset Compensation.
:FREQuency	Path to configure frequency:
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:REFerence <n>	Specify reference (REL) value (0 to 15e6).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 or 5).
:DIGits?	Query resolution.
:SOURce <name>	Select source: CURRent, VOLTage.
:SOURce?	Query source.
:THReshold	Path to configure threshold:
:CURRent	Path to set current threshold:
:RANGe <n>	Specify range (0 to 1).
:RANGe?	Query range.
:LEVel <n>	Specify threshold level.
:LEVel?	Query threshold level.

Table D-7 (cont.)
SENSe command summary

Command	Description
:FREQuency	
:THReshold	
:VOLTage	Path to set voltage threshold:
:RANGe <n>	Specify range (0 to 1000).
:RANGe?	Query range.
:LEVel <n>	Specify threshold level.
:LEVel?	Query threshold level.
:TTL	Set threshold to TTL level.
:TEMPerature	Path to configure four-wire resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line integration rate.
:REFerence <n>	Specify reference (REL) value.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 7).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:TRANsducer <name>	Select transducer: RTD, FRTD, TCouple.
:TRANSducer?	Query transducer.
:RTD	Path to configure RTD measurements:
:TYPE <name>	Select RTDS parameters: PT385, PT3916, USER.
:TYPE?	Query RTD type.
:ALPHa <NRf>	Specify constant for USER type (0 to 0.01).
:ALPHa?	Query alpha.
:BETA <NRf>	Specify constant for USER type (0 to 1).
:BETA?	Query beta.
:DELTa <NRf>	Specify constant for USER type (0 to 5).
:DELTa?	Query delta.
:RZERo <NRf>	Specify constant for USER type (0 to 1000.
:RZERo?	Query zero.

Table D-7 (cont.)
SENSe command summary

Command	Description
:TEMPerature	
:TCouple	Path to configure TC measurements:
:TYPE <name>	Select thermocouple type: J, T, K, E, R, S, B.
:TYPE?	Query TC type.
:RJUNctionX	Path to configure reference junctions (X = 1 to 5).
:RSELect <name>	Select reference type: SIMulated, REAL.
:RSELect?	Query reference type.
:SIMulated <n>	Specify simulated temperature.
:SIMulated?	Query simulated temperature.
:REAL	Command path to specify "real" reference junction.
:TCOefficient <n>	Specify TC.
:TCOefficient?	Query TC.
:OFFSet <n>	Specify voltage offset at 0°C.
:OFFSet?	Query voltage offset.
:ACQuire	Update reference temperature.
:SENSe2	
:TTL[1]	Path to read digital input port:
:DATA?	Query (read) the digital input port.

Table D-8
SOURce command summary

Command	Description
:SOURce	
:TTL[1][:LEVel] <b>	Set digital output #1 true (1 or ON) or false (0 or OFF).
:TTL[1][:LEVel]?	Query digital output line 1.
:TTL2[:LEVel] <b>	Set digital output #2 true (1 or ON) or false (0 or OFF).
:TTL2[:LEVel]?	Query digital output line 2.
:TTL3[:LEVel] <b>	Set digital output #3 true (1 or ON) or false (0 or OFF).
:TTL3[:LEVel]?	Query digital output line 3.
:TTL4[:LEVel] <b>	Set digital output #4 true (1 or ON) or false (0 or OFF).
:TTL4[:LEVel]?	Query digital output line 4.

Table D-9
STATus command summary

Command	Description
:STATus	
:MEASurement	Path to control measurement event register:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.

Table D-9 (cont.)
STATus command summary

Command	Description
:STATus	
:OPERation	Path to control operation event register:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Read the most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Read the enabled messages.
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Read the disabled messages.
:CLEar	Clears all messages from Error Queue.

Table D-10
SYSTem command summary

Command	Description
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.
:POSetup?	Query power-on setup.
FRSWitch?	Query INPUTS switch (0 = rear, 1 = front).
:VERSion?	Query rev level of SCPI standard.
:ERRor?	Query (rear) Error Queue.
:AZERo	Path to set up auto-zero.
:TYPE <name>	Select auto-zero mode: NORMal, SYNChronous.
:TYPE?	Query auto-zero mode (0 or 1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) auto-zero.
:STATe?	Query auto-zero (0 or 1).
:AMEThod <name>	Select reading acquisition method: BURSt, NORMal, ASTReam, SSTReam.
:AMEThod?	Query acquisition method.
:LSYNc	Path to control line synchronization of measurements.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) line sync.
:STATe?	Query line sync (0 or 1).
:KEY <NRf>	Simulate key-press (1 to 31; see Figure 4-40).
:KEY?	Query the last "pressed" key.
:CLEar	Clears messages from the Error Queue.
:FETCh	Path to set fetch format:
:FORMat <name>	Select format for :FETCh? command; SCPI or FRESh.

Table D-11
TRACe command summary

Command	Description
:TRACe|:DATA	Use :TRACe or :DATA as root command.
:CLEar [BUFFER,]	Clear readings from buffer.
:FREE? [BUFFER,]	Query bytes available and bytes in use.
:EGRoup [BUFFER,] <name>	Select element group: FULL, COMPact.
:EGRoup? [BUFFER,]	Query element group.
:POINts [BUFFER,] <n>	Specify size of buffer.
:AUTO [BUFFER,] <b>	Enable (1 or ON) or disable auto buffer sizing.
:AUTO? [BUFFER,]	Query state of auto buffer sizing.
:POINts? [BUFFER,]	Query buffer size.
:FEED [BUFFER,] <name>	Select source of readings: SENSe[1], CALCulate[1], NONE.
:PRETrigger	Path to configure pre-trigger storage mode.
:AMOunt	Path to specify number of pre-trigger readings.
[:PERCent] [BUFFER,] <n>	Specify as a % (0 to 100) of buffer.
[:PERCent]? [BUFFER,]	Query percentage.
:READings [BUFFER,] <n>	Specify as a number.
:READings? [BUFFER,]	Query number of readings.
:SOURce [BUFFER,] <name>	Select pre-trigger source event: EXTernal, TLINk, BUS, MANual.
:SOURce? [BUFFER,]	Query pre-trigger source event.
:CONTrol [BUFFER,] <name>	Select buffer control mode: NEVer, NEXT, ALWays, PRETrigger.
:CONTrol? [BUFFER,}	Query buffer control mode.
:FEED/ [BUFFER,]	Query source of readings for buffer.
:DATA? [BUFFER,}	Read all readings in the buffer.

Table D-12
Trigger command summary

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or oN) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Loop around control source.
:COUNt <n>	Program arm count (1 to 99999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:LAYer2	Path to program arm layer 2:
:IMMediate	Loop around control source.
:COUNt <n>	Program scan count (1 to 99999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 999999.999 sec).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 999999.999 sec).
:TIMer?	Query timer.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Loop around control source.
:COUNt <n>	Program measure count (1 to 99999, or INF).
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 999999.999 sec).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 999999.999 sec).
:TIMer?	Request the programmed timer interval.
:SIGnal	Loop around control source.

Table D-12 (cont.)
Trigger command summary

Command	Description
:TRIGger[:SEQuence[1]]	
:TCONfigure	Path to configure Triggers:
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.
:PROTocol?	Query protocol.
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:SSYNchronous	Path to configure semi-synchronous Trigger Link:
:LINE <NRf>	Select trigger line (1 to 6).
:LINE?	Query trigger line.

Table D-13
UNIT command summary

Command	Description
:UNIT	
:TEMPerature <name>	Select temperature measurement units: C, CEL, F, FAR, K.
:TEMPerature?	Query temperature units.
:VOLTage	Path to configure ACV units.
:AC <name>	Select ACV measurement units: V, DB, DBM.
:DB	Path to set DB reference voltage.
:REFerence <n>	Specify reference in volts.
:REFerence?	Query DB reference.
:DBM	Path to set DBM reference impedance.
:IMPedance <n>	Specify reference impedance.
:IMPedance?	Query DBM reference impedance.
:AC?	Query ACV units.

E

Interface Function Codes

The interface function codes, which are part of the IEEE-488 standards, define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual. The interface function codes for the Model 2001 are listed in Table E-1. The codes define Model 2001 capabilities as follows:

SH (Source Handshake Function) — SH1 defines the ability of the instrument to initiate the transfer of message/data over the data bus.

AH (Acceptor Handshake Function) — AH1 defines the ability of the instrument to guarantee proper reception of message/data transmitted over the data bus.

T (Talker Function) — The ability of the instrument to send data over the bus to other devices is provided by the T function. Instrument talker capabilities (T5) exist only after the instrument has been addressed to talk.

L (Listener Function) — The ability for the instrument to receive device-dependent data over the bus from other devices is provided by the L function. Listener capabilities (L4) of the instrument exist only after it has been addressed to listen.

SR (Service Request Function) — SR1 defines the ability of the instrument to request service from the controller.

RL (Remote-Local Function) — RL1 defines the ability of the instrument to be placed in the remote or local modes.

PP (Parallel Poll Function) — The instrument does not have parallel polling capabilities (PP0).

DC (Device Clear Function) — DC1 defines the ability of the instrument to be cleared (initialized).

DT (Device Trigger Function) — DTI defines the ability of the Model 182 to have readings triggered.

C (Controller Function) — The instrument does not have controller capabilities (C0).

TE (Extended Talker Function) — The instrument does not have extended talker capabilities (TE0).

LE (Extended Listener Function) — The instrument does not have extended listener capabilities (LE0).

E (Bus Driver Type) — The instrument has open-collector bus drivers (E1).

Table E-1
Model 2001 interface function codes

Code	Interface function
SH1	Source Handshake capability
AH1	Acceptor Handshake capability
T5	Talker (basic talker, talk-only, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service Request capability
RL1	Remote/Local capability
PP0	No Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No Controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capability
LE0	No Extended Listener capability

F

ASCII Character Codes and IEEE-488 Multiline Interface Command Messages

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
0	00	NUL	
1	01	SOH	GTL
2	02	STX	
3	03	ETX	
4	04	EOT	SDC
5	05	ENQ	PPC
6	06	ACK	
7	07	BEL	
8	08	BS	GET
9	09	HT	TCT
10	0A	LF	
11	0B	VT	
12	0C	FF	
13	0D	CR	
14	0E	SO	
15	0F	SI	

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
16	10	DLE	
17	11	DC1	LLO
18	12	DC2	
19	13	DC3	
20	14	DC4	DCL
21	15	NAK	PPU
22	16	SYN	
23	17	ETB	
24	18	CAN	SPE
25	19	EM	SPD
26	1A	SUB	
27	1B	ESC	
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	

* Message sent or received with ATN true.

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
32	20	SP	MLA 0
33	21	!	MLA 1
34	22	"	MLA 2
35	23	#	MLA 3
36	24	$	MLA 4
37	25	%	MLA 5
38	26	&	MLA 6
39	27	'	MLA 7
40	28	(	MLA 8
41	29	)	MLA 9
42	2A	*	MLA 10
43	2B	+	MLA 11
44	2C	,	MLA 12
45	2D	-	MLA 13
46	2E	.	MLA 14
47	2F	/	MLA 15
48	30	0	MLA 16
49	31	1	MLA 17
50	32	2	MLA 18
51	33	3	MLA 19
52	34	4	MLA 20
53	35	5	MLA 21
54	36	6	MLA 22
55	37	7	MLA 23
56	38	8	MLA 24
57	39	9	MLA 25
58	3A	:	MLA 26
59	3B	;	MLA 27
60	3C	<	MLA 28
61	3D	=	MLA 29
62	3E	>	MLA 30
63	3F	?	UNL

* Message sent or received with ATN true. Numbers shown represent primary address resulting in MLA (My Listen Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
64	40	@	MTA 0
65	41	A	MTA 1
66	42	B	MTA 2
67	43	C	MTA 3
68	44	D	MTA 4
69	45	E	MTA 5
70	46	F	MTA 6
71	47	G	MTA 7
72	48	H	MTA 8
73	49	I	MTA 9
74	4A	J	MTA 10
75	4B	K	MTA 11
76	4C	L	MTA 12
77	4D	M	MTA 13
78	4E	N	MTA 14
79	4F	O	MTA 15
80	50	P	MTA 16
81	51	Q	MTA 17
82	52	R	MTA 18
83	53	S	MTA 19
84	54	T	MTA 20
85	55	U	MTA 21
86	56	V	MTA 22
87	57	W	MTA 23
88	58	X	MTA 24
89	59	Y	MTA 25
90	5A	Z	MTA 26
91	5B	[	MTA 27
92	5C	\	MTA 28
93	5D	]	MTA 29
94	5E	«	MTA 30
95	5F	æ	UNL

* Message sent or received with ATN true. Numbers shown are primary address resulting in MTA (My Talk Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
96	60	«	MSA 0, PPE
97	61	a	MSA 1, PPE
98	62	b	MSA 2, PPE
99	63	c	MSA 3, PPE
100	64	d	MSA 4, PPE
101	65	e	MSA 5, PPE
102	66	f	MSA6, PPE
103	67	g	MSA 7, PPE
104	68	h	MSA 8, PPE
105	69	i	MSA 9, PPE
106	6A	j	MSA 10, PPE
107	6B	k	MSA 11, PPE
108	6C	l	MSA 12, PPE
109	6D	m	MSA 13, PPE
110	6E	n	MSA 14, PPE
111	6F	o	MSA 15, PPE
112	70	p	MSA 16, PPD
113	71	q	MSA 17, PPD
114	72	r	MSA 18, PPD
115	73	s	MSA 19, PPD
116	74	t	MSA 20, PPD
117	75	u	MSA 21, PPD
118	76	v	MSA 22, PPD
119	77	w	MSA 23, PPD
120	78	x	MSA 24, PPD
121	79	y	MSA 25, PPD
122	7A	z	MSA 26, PPD
123	7B	{	MSA 27, PPD
124	7C	|	MSA 28, PPD
125	7D	}	MSA 29, PPD
126	7E	~	MSA 30, PPD
127	7F	DEL	

* Message sent or received with ATN true. Numbers represent secondary address resulting in MSA (My Secondary Address).

G

Controller Programs

The following programs have been supplied as a simple aid to the user and are not intended to suit specific needs. Each program allows you to send a command message to the instrument and obtain and display a response from the instrument for query commands.

Programs for the following controllers are included:

- A BASIC program for an IBM PC/XT/AT with a Capital Equipment Corporation PC<>488 Interface (Keithley Model PC-488-CEC IEEE-488 Interface Card).
- A BASIC program for an IBM PC/XT/AT with IOtech Driver488 Software.
- A BASIC program for a Hewlett-Packard Model 9000 Series 200/300 computer.
- A program written with the ASYST software package (available from Keithley Instruments) for an IBM PC/XT/AT with a Capital Equipment Corporation PC<>488 Interface.
- A BASIC program for an IBM PC/XT/AT with a National GPIB PC Interface.

IBM PC/XT/AT with Capital Equipment Corporation PC<>488 Interface (Keithley PC-488-CEC)

Introduction

General information about controlling a Model 2001 with an IBM PC/XT/AT computer and Capital Equipment Corporation PC<>488 interface is given here. Refer to the CEC PC<>488 Programming and Reference Manual for complete information.

Initializing the system

The first step in any program is to initialize the system using the INITIALIZE routine. This routine sets the primary IEEE-488 bus address of the PC<>488, specifies the type of controller to be used, and sends an interface clear (IFC) to the other devices on the bus.

After booting up the IBM using DOS and entering BASICA, the statements of Program 1 can be used at the start of any program to initialize the system.

Line 30 sets the address of the PC<>488 to 21, however, any other valid address could be used as long as it does not conflict with the address of any other device on the bus.

Interface basic programming statements

This paragraph covers the PC<>488 statements that are essential to Model 2001 operation. A partial list of programming statements is contained in Table G-1. The IBM BASIC CALL statement is used to execute the desired action. Before a CALL routine can be used, BASIC needs to know the offset address of the routine. In the table, the first statement of each programming sequence defines the offset address of the CALL routine.

Example program

The following program sends a command message from an IBM PC/XT/AT computer to the Model 2001 and displays the response to a query on the CRT. The computer must be equipped with a CEC interface card and DOS 2.0 (or later revision) operating system.

Directions

1. Using the front panel MENU key, set the primary IEEE-488 address of the Model 2001 (GPIB selection) to 16.
2. With the power off, connect the Model 2001 to the IEEE-488 interface card installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into interpretive BASIC language.
4. Enter the lines of Program 2 using the return key after each line.
5. Run the program and type in the desired command string at the Enter Program Message prompt. For example, to request a reading, type in :FETCh? and press the RETURN key. The reading will appear on the computer CRT.

Table G-1
BASIC statements necessary to send bus commands

Action	PC<>488 statements
Transmit command string (CMD$) to device 16.	SEND =9 ADDRESS%=16 CALL SEND(ADDRESS%,CMD$,STATUS%)
Obtain string from device 16.	ENTER=21 ADDRESS%=16 RESPONSE$=SPACE$(50) CALL ENTER(RESPONSE$,LENGTH%,ADDRESS%,STATUS%)
Send GTL to device 16.	TRANSMIT=3 CMD$="LISTEN 16 GTL" CALL TRANSMIT(CMD$,STATUS%)
Send SDC to device 16.	TRANSMIT=3 CMD$="LISTEN 16 SDC" CALL TRANSMIT(CMD$,STATUS%)
Send DCL to all devices.	TRANSMIT=3 CMD$="LISTEN 16 DCL" CALL TRANSMIT(CMD$,STATUS%)
Send remote enable.	TRANSMIT=3 CMD$="REN LISTEN 16" CALL TRANSMIT(CMD$,STATUS%)
Serial poll device 16.	SPOLL=12 ADDRESS%=16 CALL SPOLL%(ADDRESS%,POLL%,STATUS%)

```
10    DEF SEG=&HC400                              ' Memory address.
20    INITIALIZE=0                                ' Offset address of routine.
30    MY.ADDRESS%=21                              ' Set PC<>488 address.
40    CONTROLLER%=0                               ' Set for system control.
50    CALL INITIALIZE (MY.ADDRESS%, CONTROLLER%)  ' Initialize system
```

Program 1

```
10   DEF SEG=&HC400                                              ' Memory address.
20   INITIALIZE=0                                                ' Offset address of routine.
30   SEND=9: ENTER=21
40   MY. ADDRESS%=21                                             ' Set PC<>488 address.
50   INST.ADDRESS%=16                                            ' Set 2001 address.
60   CONTROLLER%=0                                               ' Set for system control.
70   CALL INITIALIZE (MY.ADDRESS%, CONTROLLER%)                  ' Initialize system.
80   LINE INPUT "Enter Program Message"; CMD$                    ' Prompt for program message.
90   CALL SEND (INST.ADDRESS%, CMD$, STATUS%)                    ' Send command message.
100  Length = LEN (CMD$)                                         ' Determine length of input string.
110  FOR I = 1 TO Length
120  Char$ = MID$ (CMD$, I, 1)                                   ' Identify character in input string.
130  IF Char$ = "?" THEN GOTO 160                                ' If character is "?", then goto 160.
140  NEXT
150  GOTO 80                                                     ' If message is not a query, go to 80.
160  RESPONSE$=SPACE$ (80)                                       ' Make room for data.
170  CALL ENTER (RESPONSE$, LENGTH%, INST.ADDRESS%, STATUS%)     '
180  PRINT RESPONSE$                                             ' Display response message.
190  GOTO 80                                                     ' Repeat.
200  END
```

Program 2

IBM PC/XT/AT or PS/2 with IOtech Driver488 Software

Introduction

Driver488 software is an IEEE-488 driver for IBM PC and compatible computers. When combined with an IEEE-488 interface board, the package can control devices from languages including BASIC, Pascal, Fortran, and C. Driver488 software is compatible with:

- IOtech GP488B or GP488/2 boards
- National Instruments GPIB-PC, PCII, PCIIA, or PCIII boards
- Capital Equipment #01000-00300 board
- IBM GPIB Adapter

The following GW-BASIC program sends a command message to the Model 2001 and displays the instrument response for queries on the CRT. The computer must be equipped with an IEEE-488 interface board, the DOS 3.00 (or later) operating system, and a language with DOS I/O capability. Driver488 controller software must be installed and configured as described in the instruction manual.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary address of the Model 2001 to 16.
2. With power off, connect the Model 2001 to the IEEE-488 interface installed in the IBM computer.
3. Type in GWBASIC on the computer and get into the Microsoft interpretive BASIC language.
4. Enter the lines below using the return key after each line.
5. Run the program and type in the desired command string at the Enter Program Message prompt. For example, to request a reading, type in :FETCh? and press the RETURN key. The reading will be displayed on the CRT.

```
IOTECH
 10   OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1          ' Open file for output.
 20   IOCTL#1, "BREAK"                              ' Reset.
 30   PRINT#1,"RESET"
 35   PRINT #1, "TERM LF EOI"
 40   OPEN "\DEV\IEEEIN" FOR INPUT AS #2            ' Open file for input.
 50   PRINT#1, "FILL ERROR"                         ' Enable Sequence error detect
 60   LINE INPUT "Enter Program Message ";A$        ' Prompt for and get commands.
 70   IF LEN(A$)=0 THEN 140                         ' Check for null.
 80   PRINT #1,"OUTPUT 16;"+A$                      ' Send commands.
 90   Length = LEN(A$)                              ' Determine length of string.
100   FOR I = 1 TO Length                           ' Identify character in string.
110   Char$ = MID$(A$, I, 1)
120   IF Char$ ="?" THEN GOTO 150                   ' If "?", then goto 150.
130   NEXT
140   GOTO 60                                       ' If not a query, goto 60.
150   PRINT #1,"ENTER 16"                           ' Address 2001 to talk.
160   LIN E INPUT#2,B$                              ' Display response message.
170   PRINT B$
180   GOTO 60                                       ' Repeat.
190   END
```

Hewlett-Packard Model 9000 Series 200/300

Introduction

The following program sends a command message to the Model 2001 from a Hewlett-Packard Model 9000 Series 200/300 computer and displays the response to queries on the computer CRT. The computer must be equipped with HP BASIC 4.0.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary IEEE-488 address of the Model 2001 to 16.
2. With the power off, connect the Model 2001 to the IEEE-488 interface card installed in the HP computer.
3. Enter the lines in the program below, using the ENTER/RETURN key after each line.
4. Press the RUN key and type in the desired command string at the Enter Program Message prompt. For example, to request a reading, type :FETCh? and press the return key. The reading will be displayed on the CRT.

```
HP 300
 10    DIM A$[50]
 20    REMOTE 716                              ! Place 2001 in remote.
 30    LINPUT "Enter Program Message ", A$     ! Prompt for command.
 40    OUTPUT 716; A$                          ! Send command.
 50    L=LEN(A$)                               ! Dermine length of input string.
 60    FOR I = 1 TO L
 70    IF A$[I,I] = "?" THEN GOTO 100          ! If command is a query, goto 100.
 80    NEXT I
 90    GOTO 30                                 ! If not a query, goto 30.
100    ENTER 716; B$                           ! Address 2001 to talk.
110    PRINT B$                                ! Display response message.
120    GOTO 30                                 ! Repeat.
130    END
```

IBM PC/XT/AT or Compatible with CEC PC<>488 Interface and ASYST Software

Introduction

ASYST contains analysis, graphing, and data acquisition software in three integrated modules. Minimum requirements for ASYST include:

- IBM PC/XT/AT or 100% compatible (including PS/2, 386 or 486-based computers in real mode)
- DOS 2.0 (DOS 3.0 or above recommended)
- Intel 8087, 80287, or 80387 math coprocessor
- 640K RAM
- 25-pin parallel port
- Hard disk and one floppy
- IBM CGA, EGA, VGA, or 100% compatible; Hercules monochrome graphics
- LIM (Lotus/Intel/Microsoft) expanded memory is recommended

For this example, an optional software module is required for IEEE-488 interfacing. The computer must also be equipped with a CEC interface card (PC<>488 Model 300 or 310, or 4 × 488).

The ASYST program listed here sends a command string from an IBM computer to the Model 2001 and displays the response for queries on the computer's CRT.

Directions

1. Using the front panel menu, set the primary address of the Model 2001 to 16.
2. With the power off, connect the Model 2001 to the IEEE-488 interface card installed in the IBM computer.
3. Boot ASYST software. Enter the Main Configuration Menu: use the <F2> key from the OK prompt, or select CONFIG from the menu bar.
4. In addition to the usual configuration requirements of ASYST, the GPIB must be configured. From the Overlay Configuration menu, select GPIB from the Available Overlays list; then select GPIB Master and Type 1 NEC GPIB driver from the pop-up menu.
5. From the GPIB Configuration menu, select a bus number, the board number for a Capital Equipment PC<>488 (NEC uPD7210 type), a primary address (0), the hexadecimal I/O address (2B8, also known as the memory address), and an unused interrupt line.
6. Save your changes and return to the OK prompt or the menu bar.
7. Use the command line editor to enter the example program. From the OK prompt, type EDIT 2001.DMO; from the menu bar, select EDIT and type 2001.DMO. Save the program and exit the editor.
8. When prompted, load the program with the L key, or type LOAD 7001.DMO from the OK prompt.
9. When the program loads properly, type MAIN from the OK prompt to start execution.
10. Type in the desired command string at the "Enter command string:" prompt.
11. Type <Control-Break> to exit the program loop of 2001.DMO and return to the OK prompt. The program-defined words can be removed from the ASYST dictionary by typing FORGET 2001.

```
BUS.INIT                        \ Initialize bus
SEND.INTERFACE.CLEAR            \ Take control of bus
REMOTE.ENABLE.ON                \ Allow remote operation
SYNCHRONOUS.GPIB                \ Make sure ASYST is in sync. mode
?GPIB.DEVICES                   \ List controller parameters
16 GPIB.DEVICE 2001             \ Set 2001 address and name
        EOI.ON                  \ Enable end or identify
        EOS.ON                  \ Enable end of string terminator
        10 EOS.CHARACTER        \ Use LF terminator
        1000 TIMEOUT            \ Set timeout for 1sec
?GPIB.DEVICE                    \ List 2001 parameters
100 STRING COMMAND              \ Allocate 100 bytes for user input
1000 STRING RESPONSE            \ Allocate 1000 bytes for 2001 response

: GET.OUTPUT                    \ Definition for 2001 output
  RESPONSE GPIB.READ            \ Get response
  CR RESPONSE "TYPE             \ Display response
;

: GET.INPUT                     \ Definition for user input
  CR ." Enter command string: " \ Prompt user
  "INPUT COMMAND ":=            \ Get commands
  "?" COMMAND "WITHIN           \ Test for query
  IF 2001                       \ If query, make 2001 current device
        COMMAND GPIB.WRITE      \ Send commands to 2001
        GET.OUTPUT              \ Get response from 2001
  ELSE 2001                     \ If not query, make 2001 current device
        COMMAND GPIB.WRITE      \ Send commands to 2001
  THEN
;

: MAIN                          \ Definition for main program
  BEGIN                         \ Start loop
  ME                            \ Make controller current device
  GET.INPUT                     \ Get commands from user
  AGAIN                         \ Return for more commands
;                               \ <Control-Break> to exit
```

IBM PC/XT/AT with National GPIB PC Interface

Introduction

The following program sends a command message to the Model 2001 from an IBM PC/XT/AT computer and displays a response message on the CRT. The computer must be equipped with the National GPIB PC Interface and the DOS 2.00 (or later revision) operating system. Interface software must be installed and configured as described in the instruction manual.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary address of the Model 2001 to 16.
2. With the power off, connect the Model 2001 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Place the interface software disk in the default drive, type LOAD "DECL", and press the return key.
5. Add the lines below to lines 1-6 which are now in memory. Modify the address in lines 1 and 2, as described in the National instruction manual.
6. Run the program and type in the desired command message. For example, to request a reading, type in :FETCh? and press return. The reading will be displayed on the CRT.

```
NATIONAL
 10    CLS                                  Clear screen.
 20    NA$="GPIB0":CALL IBFIND(NA$,BRD0%)   Find board descriptor.
 30    NA$="DEV1":CALL IBFIND(NA$,M2001%)   Find instrument descriptor.
 40    V%=16:CALL IBPAD(M2001%,V%)          Set primary address to 16.
 50    V%=&H102:CALL IBPOKE(BRD0%,V%)       Set timeouts.
 60    V%=1:CALL IBSRE(BRD0%,V%)            Set REN true.
 70    INPUT "Enter Program Message ";CMD$  Prompt for commands.
 80    IF CMD$="EXIT" THEN 210              See if program is to be halted.
 90    IF CMD$="" THEN 70                   Check for null input.
100    CALL IBWRT (M2001%,CMD$)             Send command string.
110    Length = LEN(CMD$)                   Determine length of input string.
120    FOR I = 1 TO Length
130    Char$ = MID$(CMD$, I, 1)             Identify character in string.
140    IF Char$ = "?" THEN GOTO 170         If "?", then goto 170.
150    NEXT
160    GOTO 70                              If not a query, goto 70.
170    RD$=SPACE$(100)                      Define reading input buffer.
180    CALL IBRD(M2001%,RD$)                Address 2001 to talk.
190    PRINT RD$                            Display response message.
200    GOTO 70                              Repeat.
210    V%=0:CALL IBONL(M2001%,V%)           Close instrument file.
220    CALL IBONL(BRD0%,V%)
230    END
```

H

IEEE-488 Bus Overview

Introduction

Basically, the IEEE-488 bus is simply a communication system between two or more electronic devices. A device can be either an instrument or a computer. When a computer is used on the bus, it serves to supervise the communication exchange between all the devices and is known as the controller. Supervision by the controller consists of determining which device will talk and which device will listen. As a talker, a device will output information and as a listener, a device will receive information. To simplify the task of keeping track of the devices, a unique address number is assigned to each one.

On the bus, only one device can talk at a time and is addressed to talk by the controller. The device that is talking is known as the active talker. The devices that need to listen to the talker are addressed to listen by the controller. Each listener is then referred to as an active listener. Devices that do not need to listen are instructed to unlisten. The reason for the unlisten instruction is to optimize the speed of bus information transfer since the task of listening takes up bus time.

Through the use of control lines, a handshake sequence takes place in the transfer process of information from a talker to a listener. This handshake sequence helps ensure the credibility of the information transfer. The basic handshake sequence between an active controller (talker) and a listener is as follows:

1. The listener indicates that it is ready to listen.
2. The talker places the byte of data on the bus and indicates that the data is available to the listener.
3. The listener, aware that the data is available, accepts the data and then indicates that the data has been accepted.
4. The talker, aware that the data has been accepted, stops sending data and indicates that data is not being sent.
5. The listener, aware that there is no data on the bus, indicates that it is ready for the next byte of data.

Bus description

The IEEE-488 bus, which is also frequently referred to a the GPIB (General Purpose Interface Bus), was designed as a parallel transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and with most commands. Five bus management lines and three handshake lines round out the complement of bus signal lines

A typical set up for controlled operation is shown in Figure H-1. Generally, a system will contain one controller and a number of other instruments to which the commands are given. Device operation is categorized into three operators: controller, talker and listener. The controller does what its name implies; it controls the instruments on the bus. The talker sends data while a listener receives data. Depending on the type of instrument, any particular device can be a talker only, a listener only or both a talker and listener.

There are two categories of controllers: system controller, and basic controller. Both are able to control other instruments, but only the system controller has the absolute authority in the system. In a system with more than one controller, only one controller may be active at any given time. Certain protocol is used to pass control from one controller to another.

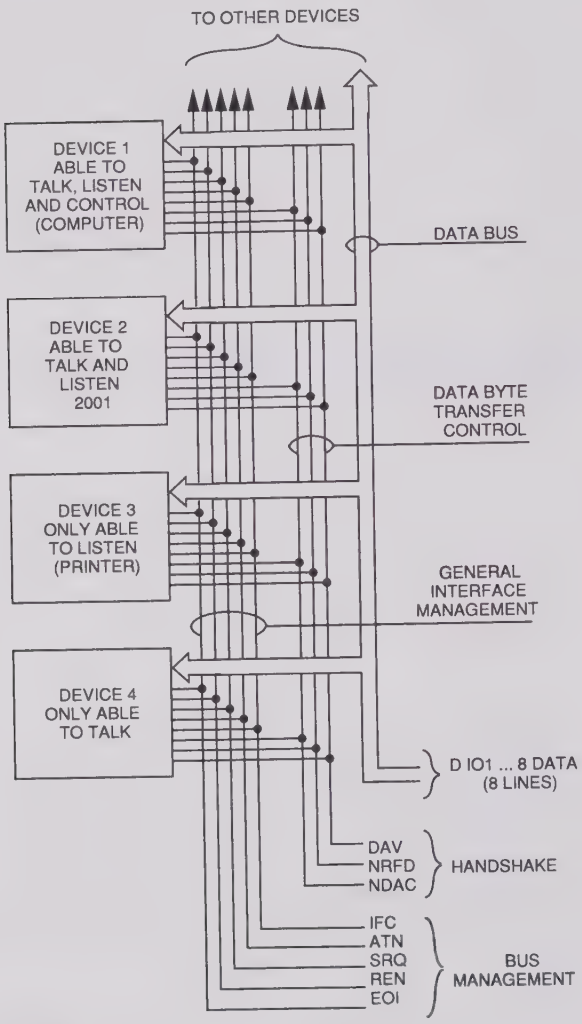


Figure H-1
IEEE-488 bus configuration

The IEEE-488 bus is limited to 15 devices, including the controller. Thus, any number of talkers and listeners up to that limit may be present on the bus at one time. Although several devices may be commanded to listen simultaneously, the bus can have only one active talker, or communications would be scrambled.

A device is placed in the talk or listen state by sending an appropriate talk or listen command. These talk and listen commands are derived from an instrument's primary address. The primary address may have any value between 0 and 31, and is generally set by rear panel DIP switches or programmed in from the front panel of the instrument. The actual listen address value sent out over the bus is obtained by ORing the primary address with $20. For example, if the primary address is $16, the actual listen address is $36 ($36 = $16 + $20). In a similar manner, the talk address is obtained by ORing the primary address with $40. With the present example, the talk address derived from a primary address of 16 decimal would be $56 ($56 = $16 + $40).

The IEEE-488 standards also include another addressing mode called secondary addressing. Secondary addresses lie in the range of $60-$7F. Note, however, that many devices, including the Model 7001, do not use secondary addressing.

Once a device is addressed to talk or listen, the appropriate bus transactions take place. For example: if the instrument is addressed to talk, it places its data string on the bus one byte at a time. The controller reads the information and the appropriate software can be used to direct the information to the desired location.

Bus lines

The signal lines on the IEEE-488 bus are grouped into three different categories: data lines, management lines and handshake lines. The data lines handle bus data and commands, while the management and handshake lines ensure that proper data transfer and operation takes place. Each bus line is active low, with approximately zero volts representing a logic 1 (true). The following paragraphs describe the operation of these lines.

Data lines

The IEEE-488 bus uses eight data lines that transfer data one byte at a time. DIO1 (Data Input/Output) through DIO8 (Data Input/Output) are the eight data lines used to transmit both data and multiline commands and are bidirectional. The data lines operate with low true logic.

Bus management lines

The five bus management lines help to ensure proper interface control and management. These lines are used to send the uniline commands.

ATN (Attention) — The ATN line is one of the more important management lines in that the state of this line determines how information on the data bus is to be interpreted.

IFC (Interface Clear) — As the name implies, the IFC line controls clearing of instruments from the bus.

REN (Remote Enable) — The REN line is used to place the instrument on the bus in the remote mode.

EOI (End or Identify) — The EOI is usually used to mark the end of a multi-byte data transfer sequence.

SRQ (Service Request) — This line is used by devices when they require service from the controller.

Handshake lines

The bus handshake lines operate in an interlocked sequence. This method ensures reliable data transmission regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the three handshake lines is controlled by the source (the talker sending information), while the remaining two lines are controlled by accepting devices (the listener or listeners receiving the information). The three handshake lines are:

DAV (DATA VALID) — The source controls the state of the DAV line to indicate to any listening devices whether or not data bus information is valid.

NRFD (Not Ready For Data) — The acceptor controls the state of NRFD. It is used to signal to the transmitting device to hold off the byte transfer sequence until the accepting device is ready.

NDAC (Not Data Accepted) — NDAC is also controlled by the accepting device. The state of NDAC tells the source whether or not the device has accepted the data byte.

The complete handshake sequence for one data byte is shown in Figure H-2. Once data is placed on the data lines, the source checks to see that NRFD is high, indicating that all active devices are ready. At the same time, NDAC should be low from the previous byte transfer. If these conditions are not met, the source must wait until NDAC and NRFD have the correct status. If the source is a controller, NRFD and NDAC must be stable for at least 100nsec after ATN is set true. Because of the possibility of a bus hang up, many controllers have time-out routines that display messages in case the transfer sequence stops for any reason.

Once all NDAC and NRFD are properly set, the source sets DAV low, indicating to accepting devices that the byte on the data lines is now valid. NRFD will then go low, and NDAC will go high once all devices have accepted the data. Each device will release NDAC at its own rate, but NDAC will not be released to go high until all devices have accepted the data byte.

The sequence just described is used to transfer both data, talk and listen addresses, as well as multiline commands. The state of the ATN line determines whether the data bus contains data, addresses or commands as described in the following paragraph.

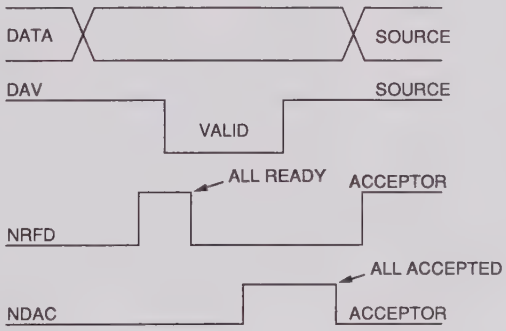


Figure H-2
IEEE-488 handshake sequence

Bus commands

The instrument may be given a number of special bus commands through the IEEE-488 interface. This section briefly describes the purpose of the bus commands which are grouped into the following three categories.

1. Uniline Commands — Sent by setting the associated bus lines true. For example, to assert REN (Remote Enable), the REN line would be set low (true).
2. Multiline Commands — General bus commands which are sent over the data lines with the ATN line true (low).
3. Common Commands — Commands that are common to all devices on the bus; sent with ATN high (false).
4. SCPI Commands — Commands that are particular to each device on the bus; sent with ATN (false).

These bus commands and their general purpose are summarized in Table H-1.

Table H-1
IEEE-488 bus command summary

Command type	Command	State of ATN line	Comments
Uniline	REN (Remote Enable)	X	Set up devices for remote operation.
	EOI	X	Marks end of transmission.
	IFC (Interface Clear)	X	Clears interface.
	ATN (Attention)	Low	Defines data bus contents.
	SRQ	X	Controlled by external device.
Multiline Universal	LLO (Local Lockout)	Low	Locks our local operation.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Enable)	Low	Enables serial polling.
	SPD (Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (Selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go To Local)	Low	Returns device to local.
Unaddressed	UNL (Unlisten)	Low	Removes all listeners from the bus.
	UNT (Untalk)	Low	Removes any talkers from the bus.
Common	—	High	Programs IEEE-488.2 compatible instruments for common operations.
SCPI	—	High	Programs SCPI compatible instruments for particular operations.

Uniline commands

ATN, IFC and REN are asserted only by the controller. SRQ is asserted by an external device. EOI may be asserted either by the controller or other devices depending on the direction of data transfer. The following is a description of each command. Each command is sent by setting the corresponding bus line true.

REN (Remote Enable) — REN is sent to set up instruments on the bus for remote operation. When REN is true, devices will be removed from the local mode. Depending on device configuration, all front panel controls except the LOCAL button (if the device is so equipped) may be locked out when REN is true. Generally, REN should be sent before attempting to program instruments over the bus.

EOI (End or Identify) — EOI is used to positively identify the last byte in a multi-byte transfer sequence, thus allowing data words of various lengths to be transmitted easily.

IFC (Interface Clear) — IFC is used to clear the interface and return all devices to the talker and listener idle states.

ATN (Attention) — The controller sends ATN while transmitting addresses or multiline commands.

SRQ (Service Request) — SRQ is asserted by a device when it requires service from a controller.

Universal multiline commands

Universal commands are those multiline commands that require no addressing. All devices equipped to implement such commands will do so simultaneously when the commands are transmitted. As with all multiline commands, these commands are transmitted with ATN true.

LLO (Local Lockout) — LLO is sent to the instrument to lock out the LOCAL key and thus all their front panel controls.

DCL (Device Clear) — DCL is used to return instruments to some default state. Usually, instruments return to their power-up conditions.

SPE (Serial Poll Enable) — SPE is the first step in the serial polling sequence which is used to determine which device has requested service.

SPD (Serial Poll Disable) — SPD is used by the controller to remove all devices on the bus from the serial poll mode and is generally the last command in the serial polling sequence.

Addressed multiline commands

Addressed commands are multiline commands that must be preceded by the device listen address before that instrument will respond to the command in question. Note that only the addressed device will respond to these commands. Both the commands and the address preceding it are sent with ATN true.

SDC (Selective Device Clear) — The SDC command performs essentially the same function as the DCL command except that only the addressed device responds. Generally, instruments return to their power-up default conditions when responding to the SDC command.

GTL (Go To Local) — The GTL command is used to remove instruments from the remote mode. With some instruments, GTL also unlocks front panel controls if they were previously locked out with the LLO command.

GET (Group Execute Trigger) — The GET command is used to trigger devices to perform a specific action that depends on device configuration (for example, take a reading). Although GET is an addressed command, many devices respond to GET without addressing.

Address commands

Addressed commands include two primary command groups and a secondary address group. ATN is true when these commands are asserted. The commands include:

LAG (Listen Address Group) — These listen commands are derived from an instrument's primary address and are used to address devices to listen. The actual command byte is obtained by ORing the primary address with $20.

TAG (Talk Address Group) — The talk commands are derived from the primary address by ORing the address with $40. Talk commands are used to address devices to talk.

SCG (Secondary Command Group) — Commands in this group provide additional addressing capabilities. Many devices (including the Model 2001) do not use these commands.

Unaddress commands

The two unaddress commands are used by the controller to remove any talkers or listeners from the bus. ATN is true when these commands are asserted.

UNL (Unlisten) — Listeners are placed in the listener idle state by the UNL command.

UNT (Untalk) — Any previously commanded talkers will be placed in the talker idle state by the UNT command.

Common commands

Common commands are commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a common operation, such as reset. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

SCPI commands

SCPI commands are commands that are particular to each device on the bus. These commands are designated by the instrument manufacturer, and are based on the instrument model defined by the Standard Commands for Programmable Instruments (SCPI) Consortium's SCPI standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a particular operation, such as setting a range or closing a relay. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

Command codes

Command codes for the various commands that use the data lines are summarized in Figure H-3. Hexadecimal and the decimal values for the various commands are listed in Table H-2.

D_7 D_6 D_5 D_4					X 0 0 0	Command	X 0 0 1	Command	X 0 1 0	Primary Address	X 0 1 1	Primary Address	X 1 0 0	Primary Address	X 1 0 1		X 1 1 0		X 1 1 1	
Bits	D_3 ↓	D_2 ↓	D_1 ↓	D_0 ↓	Column→ Row ↓	0 (B)	1 (A)	1 (B)	2 (A)	2 (B)	3 (A)	3(B)	4 (A)	4 (B)	5 (A)	5 (B)	6 (B)	7 (A)	7 (B)
	0	0	0	0	0		DLE		SP	0	0	16	@	0	P	16		p	
	0	0	0	1	1	GTL	DC1	LLO	!	1	1	17	A	1	Q	17	a	q	
	0	0	1	0	2		DC2		"	2	2	18	B	2	R	18	b	r	
	0	0	1	1	3		DC3		#	3	3	19	C	3	S	19	c	s	
	0	1	0	0	4	SDC	DC4	DCL	$	4	4	20	D	4	T	20	d	t	
	0	1	0	0	5	PPC*	NAK	PPU*	%	5	5	21	E	5	U	21	e	u	
	0	1	1	0	6		SYN		&	6	6	22	F	6	V	22	f	v	
	0	1	1	1	7		ETB		'	7	7	23	G	7	W	23	g	w	
	1	0	0	0	8	GET	CAN	SPE	(	8	8	24	H	8	X	24	h	x	
	1	0	0	1	9	TCT*	EM	SPD	)	9	9	25	I	9	Y	25	i	y	
	1	0	1	0	10		SUB		*	10	:	26	J	10	Z	26	j	z	
	1	0	1	1	11		ESC		+	11	;	27	K	11	[	27	k	{	
	1	1	0	0	12		FS		,	12	<	28	L	12	\	28	l	:	
	1	1	0	1	13		GS		-	13	=	29	M	13	]	29	m	}	
	1	1	1	0	14		RS		.	14	>	30	N	14	^	30	n	≅	
	1	1	1	1	15		US		/	15	?	UNL	O	15	_	UNT	o	DEL	

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

PRIMARY COMMAND GROUP (PCG)

SECONDARY COMMAND GROUP (SDC)

*PPC (PARALLEL POLL CONFIGURE) PPU (PARALLEL POLL UNCONFIGURE), and TCT (TAKE CONTROL) not implemented by Model 2001.
Note: D_0 = DIO1 ... D_7 = DIO8; X = Don't Care.

Figure H-3
Command codes

Table H-2
Hexadecimal and decimal command codes

Command	Hex value	Decimal value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
SCG	60-7F	96-127
UNL	3F	63
UNT	5F	95

For the various multiline commands, a specific bus sequence must take place to properly send the command. In particular, the correct listen address must be sent to the instrument before it will respond to addressed commands. Table H-3 lists a typical bus sequence for sending the addressed multiline commands. In this instance, the SDC command is being sent to the instrument. UNL is generally sent as part of the sequence to ensure that no other active listeners are present. Note that ATN is true for both the listen command and the SDC command byte itself

Table H-4 gives a typical common command sequence. In this instance, ATN is true while the instrument is being addressed, but it is set high while sending the common command string.

Table H-3
Typical addressed command sequence

Step	Command	ATN state	Data bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	0	30	48
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 16.

Table H-4
Typical common command sequence

Step	Command	ATN state	Data bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	0	30	48
3	Data	Set high	*	2A	42
4	Data	Stays high	R	52	82
5	Data	Stays high	S	53	83
6	Data	Stays high	T	54	84

Assumes primary address = 16.

IEEE command groups

Command groups supported by the Model 2001 are listed in Table H-5. Common commands and SCPI commands are not included in this list.

Table H-5
IEEE command groups

HANDSHAKE COMMAND GROUP	
	NDAC = NOT DATA ACCEPTED
	NRFD = NOT READY FOR DATA
	DAV = DATA VALID
UNIVERSAL COMMAND GROUP	
	ATN = ATTENTION
	DCL = DEVICE CLEAR
	IFC = INTERFACE CLEAR
	REN = REMOTE ENABLE
	SPD = SERIAL POLL DISABLE
	SPE = SERIAL POLL ENABLE
ADDRESS COMMAND GROUP	
LISTEN	LAG = LISTEN ADDRESS GROUP
	MLA = MY LISTEN ADDRESS
	UNL = UNLISTEN
TALK	TAG = TALK ADDRESS GROUP
	MTA = MY TALK ADDRESS
	UNT = UNTALK
	OTA = OTHER TALK ADDRESS
ADDRESSED COMMAND GROUP	
	ACG = ADDRESSED COMMAND GROUP
	GTL = GO TO LOCAL
	SDC = SELECTIVE DEVICE CLEAR
STATUS COMMAND GROUP	
	RQS = REQUEST SERVICE
	SRQ = SERIAL POLL REQUEST
	STB = STATUS BYTE
	EOI = END

I

IEEE-488 Conformance Information

Information

The IEEE-488.2 standard requires specific information about how the Model 2001 implements the standard. Paragraph 4.9 of the IEEE-488.2 standard (Std 488.2-1987) lists the documentation requirements. Table H-1 provides a summary of the requirements, and provides the information or references the manual for that information.

Table I-1
IEEE-488 documentation requirements

	Requirement	Description or reference
(1)	IEEE-488 Interface Function Codes.	See Appendix E
(2)	Behavior of 2001 when the address is set outside the range 0-30.	Cannot enter an invalid address.
(3)	Behavior of 2001 when valid address is entered.	Address changes and bus resets.
(4)	Power-On Setup Conditions.	Determined by :SYSTem:POSetup (para. 4.12.10).
(5)	Message Exchange Options:	
(a)	Input buffer size.	256 bytes.
(b)	Queries that return more than one response message unit.	None
(c)	Queries that generate a response when parsed.	All queries (Common Commands and SCPI).
(d)	Queries that generate a response when read.	None.
(e)	Coupled commands.	See Table I-2.
(6)	Functional elements required for SCPI commands.	Contained in SCPI command subsystems tables (see Appendix D).
(7)	Buffer size limitations for block data.	Block display messages: Top display = 20 characters max, bottom display = 32 characters max.
(8)	Syntax restrictions.	See paragraphs 4.10 thru 4.12.
(9)	Response syntax for every query command.	See paragraphs 4.9 and 4.12.
(10)	Device-to-device message transfer that does not follow rules of the standard.	None.
(11)	Block data response size.	See paragraph 4.12.4.
(12)	Common Commands implemented by 2001.	See Appendix D
(13)	Calibration query information.	See Calibration Manual.
(14)	Trigger macro for *DDT.	Not applicable.
(15)	Macro information.	Not applicable.
(16)	Response to *IDN (identification).	See paragraph 4.9.5.
(17)	Storage area for *PUD and *PUD?	Not applicable.
(18)	Resource description for *RDT and *RDT?	Not applicable.

Table I-1 (cont.)
IEEE-488 documentation requirements

	Requirement	Description or reference
(19)	Effects of *RST, *RCL and *SAV.	See Appendix B.
(20)	*TST information.	See paragraph 4.9.16.
(21)	Status register structure.	See paragraph 4.6.
(22)	Sequential or overlapped commands.	All are sequential except :INIT and :INIT:CONT ON, which are overlapped.
(23)	Operation complete messages.	*OPC; see paragraph 4.9.6, *OPC?; see paragraph 4.9.7, *WAI; see paragraph 4.9.17.

Table I-2
Coupled commands

Command	Also changes	To	If
:SYST:AMET BURS	... :RANG:AUTO	OFF	
	... :NPLC	0.01	
	... :APER	0.01 / line-frequency	
	... :DIG:AUTO	OFF	
	... :DIG	4	
	... :AVER:AUTO	OFF	
	... :AVER:TCON	MOV	
	:INIT:CONT	OFF	
	:SYST:AZER:STAT	OFF	
	:ARM:LAY1:COUN	1	
	:ARM:LAY2:COUN	1	
	:TRIG:COUN	TRACe:POIN	
	:TRACe:EGR	COMP	
	:TRACe:FEED	CALC1	TRACe:FEED is NONE
	:TRACe:FEED:CONT	NEXT	
:SYST:AMET:ASTR	:SYST:AZER:STAT	OFF	
and	:SYST:LSYN:STAT	OFF	
:SYST:AMET:SSTR	:CALC:STAT	OFF	
	... :RANG:AUTO	OFF	
	... :NPLC	0.01	
	... :NPLC:AUTO	OFF	
	... :DIG	4	
	... :DIG:AUTO	OFF	
	... :AVER:STAT	OFF	
	... :AVER:AUTO	OFF	
	... :REF:STAT	OFF	
:TRIG:COUN	:TRAC:POIN:AUTO	OFF	TRAC:POIN:AUTO is ON and TRIG:COUN is an illegal buffer size
	:TRAC:POIN	TRIG:COUN	TRAC:POIN:AUTO is ON
	:TRAC:FEED:PRET:AMO:READ	TRIG:COUN * TRAC:FEED:PRET:AMO: PERC / 100	TRAC:POIN:AUTO is ON
:TRAC:FEED:CONT	:TRIG:SOUR	TIM	TRAC:FEED:CONT is PRET and TRIG:SOUR is neither IMM nor TIM

Table I-2 (cont.)
Coupled commands

Command	Also changes	To	If
:TRAC:POIN	:TRAC:POIN:AUTO	OFF	
	:TRAC:FEED:CONT	NEV	
	:TRAC:FEED:PRET:AMO:READ	TRAC:POIN * TRAC :FEED:PRET:AMO :PERC / 100	
	:TRIG:COUN	TRAC:POIN	SYST:AMET is BURS
:TRAC:FEED:PRET:AMO:PERC	:TRAC:FEED:PRET:AMO:READ	TRAC:POIN * TRAC :FEED:PRET:AMO :PERC / 100	
	:TRAC:FEED:CONT	NEV	
:TRAC:FEED:PRET:AMO:READ	:TRAC:FEED:PRET:AMO:PERC	TRAC:FEED:PRET: AMO:READ / TRAC :POIN * 100	
	:TRAC:FEED:CONT	NEV	
:TRAC:EGR	:TRAC:FEED:CONT	NEV	
:TRAC:CLE	:TRAC:FEED:CONT	NEV	
:UNIT:VOLT:AC	:VOLT:AC:AVER:STAT	varies per units	VOLT:AC:AVER:AUTO is ON
	:VOLT:AC:AVER:COUN	varies per function	VOLT:AC:AVER:AUTO is ON
	:VOLT:AC:AVER:TCON	varies per function	VOLT:AC:AVER:AUTO is ON
	:VOLT:AC:AVER:ADV:STAT	varies per function	VOLT:AC:AVER:AUTO is ON
	:VOLT:AC:AVER:ADV:NTOL	varies per function	VOLT:AC:AVER:AUTO is ON
:FUNC :ROUT:OPEN:ALL			function is 4-wire and closed channel > 5
...:APER	...:APER:AUTO	OFF	
	...:NPLC:AUTO	OFF	
	...:NPLC	APER*line-frequency	
	...:DIG	varies per function	...DIG:AUTO is ON
...:NPLC	...:APER:AUTO	OFF	
	...:NPLC:AUTO	OFF	
	...:APER	NPLC/line-frequency	
	...:DIG	varies per function	...DIG:AUTO is ON
...:DIG	...:DIG:AUTO	OFF	
	...:APER	varies per function	...APER:AUTO is ON
	...:NPLC	varies per function	...NPLC:AUTO is ON
...:RANG:UPP	...:RANG:AUTO	OFF	
...:REF:ACQ	...:REF	presently displayed reading	
...:AVER:STAT	...:AVER:AUTO	OFF	
...:AVER:COUN	...:AVER:AUTO	OFF	
...:AVER:TCON	...:AVER:AUTO	OFF	
...:AVER:ADV:NTOL	...:AVER:AUTO	OFF	
...:AVER:ADV:STAT	...:AVER:AUTO	OFF	
...:DET:FUNC	...:APER	varies per function	...APER:AUTO is ON
	...:DIG	varies per function	...DIG:AUTO is ON
	...:AVER:STAT	varies per function	...AVER:AUTO is ON
	...:AVER:COUN n	varies per functio	...AVER:AUTO is ON
	...:AVER:TCON n	varies per functio	...AVER:AUTO is ON
	...:AVER:ADV:STAT n	varies per functio	...AVER:AUTO is ON
	...:AVER:ADV:NTOL n	varies per functio	...AVER:AUTO is ON

Table I-2 (cont.)
Coupled commands

Command	Also changes	To	If
:RES:OCOM	:RES:RANG:UPP	200k	RES:OCOM is ON and RES:RANG:UPP > 200k
	:RES:RANG:AUTO:ULIM	200k	RES:OCOM is ON and RES:RANG:AUTO:ULIM > 200k
	:RES:RANG:AUTO:LLIM	200k	RES:OCOM is ON and RES:RANG:AUTO:LLIM > 200k
:CURR:DC:METH	:CURR:DC:RANG:UPP	12	CURR:DC:METH is ICIR
	:CURR:DC:RANG:AUTO	OFF	CURR:DC:METH is ICIR
	:CURR:DC:AVER:STAT	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:COUN	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:TCON	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:ADV:STAT	varies per function	CURR:DC:AVER:AUTO is ON
	:CURR:DC:AVER:ADV:NTOL	varies per function	CURR:DC:AVER:AUTO is ON
:FREQ:THR:VOLT:TTL	:FREQ:THR:VOLT:RANG	10	
	:FREQ:THR:VOLT:LEV	0.8	
:TEMP:TRAN	:ROUT:SCAN:INT	very complicated algorithm	
	:ROUT:SCAN:INT:FUNC	very complicated algorithm	
	:TEMP:DIG	varies per transducer	TEMP:DIG:AUTO is ON
:TEMP:RTD:TYPE	:TEMP:RTD:ALPH	varies per RTD type	TEMP:RTD:TYPE is not USER
	:TEMP:RTD:BETA	varies per RTD type	TEMP:RTD:TYPE is not USER
	:TEMP:RTD:DELT	varies per RTD type	TEMP:RTD:TYPE is not USER
	:TEMP:RTD:RZER	varies per RTD type	TEMP:RTD:TYPE is not USER
:TEMP:RTD:ALPH	:TEMP:RTD:TYPE	USER	
:TEMP:RTD:BETA	:TEMP:RTD:TYPE	USER	
:TEMP:RTD:DELT	:TEMP:RTD:TYPE	USER	
:TEMP:RTD:RZER	:TEMP:RTD:TYPE	USER	
:TEMP:TC:TYPE	:TEMP:DIG	varies per TC type	TEMP:DIG:AUTO is ON
:ROUT:CLOS	:ROUT:SCAN:LSEL	NONE	
:ROUT:OPEN	:ROUT:SCAN:LSEL	NONE	the command actually opens a channel
:ROUT:OPEN:ALL	:ROUT:SCAN:LSEL	NONE	
:ROUT:SCAN:INT	:ROUT:SCAN:LSEL	INT	
:ROUT:SCAN:RAT:FUNC	...:AVER:STAT	varies per function	...AVER:AUTO is ON
	...:AVER:COUN	varies per function	...AVER:AUTO is ON
	...:AVER:TCON	varies per function	...AVER:AUTO is ON
	...:AVER:ADV:STAT	varies per function	...AVER:AUTO is ON
	...:AVER:ADV:NTOL n	varies per function	...AVER:AUTO is ON
:ROUT:SCAN:LSEL	...:AVER:STAT varies per function	varies per function	...AVER:AUTO is ON
	...:AVER:COUN	varies per function	...AVER:AUTO is ON
	...:AVER:TCON	varies per function	...AVER:AUTO is ON
	...:AVER:ADV:STAT	varies per function	...AVER:AUTO is ON
	...:AVER:ADV:NTOL	varies per function	...AVER:AUTO is ON
	:FUNC	:ROUT:SCAN:RAT:FUNC	ROUT:SCAN:LSEL is RAT
	:FUNC	:ROUT:SCAN:DELT :FUNC	ROUT:SCAN:LSEL is DELT
	:ROUT:CLOS	:ROUT:SCAN:RAT :MCH	ROUT:SCAN:LSEL is RAT
	:ROUT:CLOS	:ROUT:SCAN:DELT :MCH	ROUT:SCAN:LSEL is DELT

... = Valid function command words (i.e. :VOLT:DC, :VOLT:AC, etc.)

J

SCPI Conformance Information

Introduction

The Model 2001 complies with SCPI version 1991.0. Table J-1 lists the SCPI confirmed commands implemented by the Model 2001, and Table J-2 lists the non-SCPI commands implemented.

Table J-1
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
:CALCulate[1]	Subsystem to control CALC 1:
:FORMat <name>	Select math format: MXB, PERCent, NONE.
:FORMat?	Query math format.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.
:STATe?	Query state of math function.
:DATA?	Read math result of CALC 1.
:IMMediate	Recalculate input data.
:CALCulate2	Subsystem to control CALC 2.
:FORMat <name>	Select math format: MEAN, SDEViation, MAXimum, MINimum, PKPK, NONE.
:FORMat?	Query math format.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.
:STATe?	Query state of math function.
:IMMediate	Recalculate raw input data in buffer.
:DATA?	Read math result of CALC 2.
:CALCulate3	Subsystem to control CALC 3 (limit tests):
:LIMit[1]	Path to control LIMIT 1 test:
:UPPer	Path to configure upper limit:
[:DATA] <n>	Specify upper limit (-9.99e35 to +9.99e35).
[:DATA]?	Query upper limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source.
:LOWer	Path to configure lower limit:
[:DATA] <n>	Specify lower limit (-9.99e35 to +9.99e35).
[:DATA]?	Query lower limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source.

Table J-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
:CALCulate3	
:LIMit[1]	
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.
:STATe?	Query state of limit test.
:FAIL?	Query test result (1 = pass, 0 = fail).
CLEAR	Path to clear failed test:
[:IMMediate]	Clear failed test indication.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.
:AUTO?	Query auto clear.
:LIMit2	Path to control LIMIT 2 test:
:UPPer	Path to configure upper limit:
[:DATA] <n>	Specify upper limit (-9.99e35 to +9.999999e35).
[:DATA]?	Query upper limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source (digital output value).
:LOWer	Path to configure lower limit:
[:DATA] <n>	Specify lower limit (-9.99e35 to +9.999999e35).
[:DATA]?	Query lower limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source (digital output value).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.
:STATe?	Query state of limit test.
:FAIL?	Query test result (1 = pass, 0 = fail).
:CLEAR	Path to clear failed test:
[:IMMediate]	Clear failed test indication.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.
:AUTO?	Query auto clear.
:IMMediate	Re-perform limit tests.
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display.
:ENABle?	Query state of the display (0 or 1).
:FORMat	
[:DATA] <type>[,<length>]	Select data format: ASCii, REAL, 32, REAL, 64, SREal or DREal.
[:DATA]?	Query data format.
:BORDer <name>	Select binary byte order: NORMal, SWAPped.
:BORDer?	Query byte order.

Table J-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
:ROUTe	
:CLOSe <list>	Path and command to close specified channel:
:STATe?	Query closed channel.
:CLOSe? <list>	Query specified channels (1 = closed, 0 = open).
:OPEN <list>	Open specified channel or all channels.
:OPEN:ALL	Open all channels.
:OPEN <list>	Query specified channels (1 = open, 0 = closed).
:SCAN	Command path to configure and control scan operations:
[:INTernal] <list>	Specify an internal scan list (2 to 10 channels).
[:INTernal]?	Query the internal scan list.
[:SENSe[1]]	
:FUNCtion <name>	Select measurement function: 'VOLTage:AC', 'VOLTage:DC', RESistance','CURRent:AC', 'CURRent:DC', 'FREQuency', TEMPerature'
:FUNCtion?	Query function.
:DATA?	Query latest reading.
:CURRent:AC	Path to configure AC current:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +2.1).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:REFerence?	Query reference (REL) value.
:CURRent:DC	Path to configure DC current.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +2.1).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:REFerence?	Query reference (REL) value.
:VOLTage:AC	Path to configure AC voltage.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:NPLCycles?	Query line cycle integration rate.

Table J-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:VOLTage:AC	
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +775).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-775 to +775).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:REFerence?	Query reference (REL) value.
:VOLTage:DC	Path to configure DC voltage:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +1100).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-1100 to +1100).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:REFerence?	Query reference (REL) value.
:RESistance	Path to configure resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +1.05e9).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-1.05e9 to +1.05e9).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:REFerence?	Query reference (REL) value.
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.
:OCOMpensated?	Query Offset Compensation.
:FRESistance	Path to configure four-wire resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +2.1e5).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:AUTO?	Query auto range.

Table J-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:FRESistance	
:REFerence <n>	Specify reference (REL) value (-2.1e5 to +2.1e5).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:REFerence?	Query reference (REL) value.
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.
:OCOMpensated?	Query Offset Compensation.
:STATus	
:OPERation	Path to control operation event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:TRIGger	Path to control the trigger event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.

Table J-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
:STATus	
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Read the most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Read the enabled messages.
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:VERSion?	Query rev level of SCPI standard.
:ERRor?	Query (rear) Error Queue.
:KEY <NRf>	Simulate key-press (1 to 31; see Figure 4-40).
:KEY?	Query the last "pressed" key.
:TRACe|:DATA	Use :TRACe or :DATA as root command.
:FREE? [BUFFER,]	Query bytes available and bytes in use.
:POINts [BUFFER,] <n>	Specify size of buffer.
:AUTO [BUFFER,] <b>	Enable (1 or ON) or disable auto buffer sizing.
:AUTO? [BUFFER,]	Query state of auto buffer sizing.
:POINts? [BUFFER,]	Query buffer size.
:FEED [BUFFER,] <name>	Select source of readings: SENSe[1], CALCulate[1], NONE.
:CONTrol [BUFFER,] <name>	Select buffer control mode: NEVer, NEXT, ALWays, PRETrigger.
:CONTrol? [BUFFER,]	Query buffer control mode.
:FEED? [BUFFER,]	Query source of readings for buffer.
:DATA? [BUFFER,]	Read all readings in the buffer.
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Loop around control source.
:COUNt <n>	Program arm count (1 to 99999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:LAYer2	Path to program arm layer 2.
:IMMediate	Loop around control source.
:COUNt <n>	Program scan count (1 to 99999, or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 999999.999 sec).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 999999.999 sec).
:TIMer?	Query timer.
:SIGNal	Loop around control source.

Table J-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 2001

Command	Description
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Loop around control source.
:COUNt <n>	Program measure count (1 to 99999, or INF).
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 999999.999 sec).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 999999.999 sec).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.
:UNIT	
:TEMPerature <name>	Select temperature measurement units: C, CEL, F, FAR, K.
:TEMPerate?	Query temperature units.

Table J-2
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
:CALCulate[1]	Subsystem to control CALC 1:
:KMATh	Path to configure math calculations:
:MMFactor <NRf>	Specify "m" for mX+b (-9.99e35 to +9.99e20).
:MMFactor?	Query "m" factor.
:MBFactor <NRf>	Specify "b" for mX+b (-9.99e35 to +9.99e30).
:MBFactor?	Query "b" factor.
:PERCent <NRf>	Set Percent value (-2.0e9 to +2.0e9).
:PERCent?	Query PERCENT.
:CALCulate3	Subsystem to control CALC3 (limit tests):
:PASS	Path to define "pass" digital output pattern.
:SOURce <NRf>	Specify digital output (0 to 15).
:BSTRobe	Path to control limit binning strobe:
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) strobe.
:STATe?	Query state of binning strobe.
:CALibration	Calibration root command.
:PROTected	All commands in this subsystem are protected by the CAL switch.
:LOCK	Lock out calibration (opposite of enabling cal with CAL switch).
:SWITch?	Request comprehensive CAL switch state. (0 = locked; 1 = unlocked)
:SAVE	Save cal constants to EEPROM.
:DATA?	Download cal constants from 2001.
:DATE "<string>"	Send cal date to 2001.
:DATE?	Request cal date from 2001.
:NDUE "<string>"	Send next due cal date to 2001.
:NDUE?	Request next due cal date from 2001.
:LLEVel	Low-level calibration subsystem.
:SWITch?	Request low-level CAL switch state. (0 = locked; 1 = unlocked)

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
:CALibration	
:PROtected	
:LLEvel	
:STEP <Step #>	
1	20V AC at 1kHz step.
2	20V AC at 30kHz step.
3	200V AC at 1kHz step.
4	200V AC at 30kHz step.
5	1.5V AC at 1kHz step.
6	0.2V AC at 1kHz step.
7	5mV AC at 100kHz step.
8	0.5mV AC at 1kHz step.
9	+2V DC step.
10	-2V DC step.
11	0V DC step.
12	20mA AC at 1kHz step.
13	+0.2A DC step.
14	+2A DC step.
15	2V AC at 1Hz step.
:STEP?	Request the current calibration step.
:CALCulate	Calculate low-level cal constants.
:DC	User calibration subsystem.
:ZERO	Low-thermal short calibration step.
:LOW <NRf>	+2V DC calibration step.
:HIGH <NRf>	+20V DC calibration step.
:LOHM <NRf>	20kΩ calibration step.
:HOHM <NRf>	1MΩ calibration step.
:OPEN	Open circuit calibration step.
:CALCulate	Calculate DC cal constants.
:UNPRotected	All commands in this subsystem are not protected by CAL switch.
:ACCompensation	Perform user AC calibration (disconnect all cables).
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:DATA?	Query data on top portion of display.
:WINDow2	Path to locate message to bottom display.
:DATA?	Query data on bottom portion of display.
:CNDisplay	Clear NEXT (or PREV) display messages and cancels associated operations.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:FORMat	
:ELEments <item list>	Specify data elements: READing, CHANnel, RNUMber, UNITs, TIMEstamp and STATus.
:ELEments?	Query data elements.
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 2.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
:OUTPut	
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 4.
:ROUTe	
:SCAN	Command path to configure and control scan operations:
[:INTernal]	Specify an internal scan list (2 to 10 channels).
:FUNCtion? <list>, <name>	Assign measurement function to specified channels.
:FUNCtion? <list>	Query function for each specified channel.
:EXTernal <list>	Specify an external scan list (2 to 80 channels).
:EXTernal?	Query the external scan list.
:FUNCtion? <list>, <name>	Assign measurement function to specified channels.
:FUNCtion? <list>	Query function for each specified channel.
:RATio	Command path to configure ratio calculation:
:RCHannel <list>	Specify reference channel (1 to 10).
:RCHannel?	Query reference channel.
:MCHannel <list>	Specify measure channel (1 to 10).
:MCHannel?	Query measure channel.
:DELTa	Command path to configure delta calculation:
:RCHannel <list>	Specify reference channel (1 to 10).
:RCHannel?	Query reference channel.
:MCHannel <list>	Specify measure channel (1 to 10).
:MCHannel?	Query measure channel.
:LSELect <name>	Select scan operation: INTernal, EXTernal, RATio, DELTa, NONE.
:LSELect?	Query scan operation.
[:SENse[1]]	
:ALTernate[1]	Path to control an Alternate setup.
:SAVE	Save current setup as Alternate setup.
:RECall	Return instrument to Alternate setup.
:CURRent:AC	Path to configure AC current.
:APERture	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:NPLCycles	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:RANGe	Path to configure measurement range:
:AUTO	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +2.1).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +2.1).
:LLIMit?	Query lower limit.
:REFerence	Specify reference (REL) value (-2.1 to +2.1).
:ACQuire	Use input signal as reference.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
[:SENse[1]]	
:CURRent:AC	
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:DETector	Path to select function:
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage.
[:FUNCtion]?	Query detector function.
:CURRent:DC	Path to configure DC current.
:APERture	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:NPLCycles	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:RANGe	Path to configure measurement range:
:AUTO	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1).
:LLIMit?	Query lower limit.
:REFerence	Specify reference (REL) value (-2.1 to +2.1).
:ACQuire	Use input signal as reference.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:CURRent:DC	
:AVERage	
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:METHod <name>	Select measurement technique: NORMal, ICIRcuit.
:METHod?	Query method.
:VOLTage:AC	Path to configure AC voltage
:APERture	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:NPLCycles	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:RANGe	Path to configure measurement range:
:AUTO	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +775).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +775).
:LLIMit?	Query lower limit.
:REFerence	Specify reference (REL) value (-775 to +775).
:ACQuire	Use input signal as reference.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:VOLTage:AC	
:DETector	Path to select function:
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage, PEAK, LFRMs, NPeak, PPeak.
[:FUNCtion]?	Query detector function.
:PWINdow <n>	Specify window in seconds (0.1 to 9.9).
:PWINdow?	Query peak spike detection window.
:VOLTage:DC	Path to configure DC voltage:
:APERture	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:NPLCycles	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:RANGe	Path to configure measurement range:
:AUTO	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +775).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +775).
:LLIMit?	Query lower limit.
:REFerence	Specify reference (REL) value (-775 to +775).
:ACQuire	Use input signal as reference.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:RESistance	Path to configure resistance:
:APERture	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:NPLCycles	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:RESistance	
:RANGe	Path to configure measurement range:
:AUTO	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 1.05e9).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 1.05e9).
:LLIMit?	Query lower limit.
:REFerence	Specify reference (REL) value (-1.05e9 to +1.05e9).
:ACQuire	Use input signal as reference.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:FRESistance	Path to configure four-wire resistance:
:APERture	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:NPLCycles	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:RANGe	Path to configure measurement range:
:AUTO	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1e5).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1e5).
:LLIMit?	Query lower limit.
:REFerence	Specify reference (REL) value (-2.1e5 to +2.1e5).
:ACQuire	Use input signal as reference.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:FRESistance	
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:FREQuency	Path to configure frequency:
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:REFerence <n>	Specify reference (REL) value (0 to 15e6).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 or 5).
:DIGits?	Query resolution.
:SOURce <name>	Select source: CURRent, VOLTage.
:SOURce?	Query source.
:THReshold	Path to configure threshold:
:CURRent	Path to set current threshold:
:RANGe <n>	Specify range (0 to 1).
:RANGe?	Query range.
:LEVel <n>	Specify threshold level.
:LEVel?	Query threshold level.
:VOLTage	Path to set voltage threshold:
:RANGe <n>	Specify range (0 to 1000).
:RANGe?	Query range.
:LEVel <n>	Specify threshold level.
:LEVel?	Query threshold level.
:TTL	Set threshold TTL level.
:TEMPerature	Path to configure four-wire resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
[:SENSe[1]]	
:TEMPerature	
:REFerence <n>	Specify reference (REL) value.
:STATe <b>	Enable (1 or oN) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 7).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable autofilter.
:AUTO?	Query auto filter.
:TRANsducer <name>	Select transducer: RTD, FRTD, TCouple.
:TRANsducer?	Query transducer.
:RTD	Path to configure RTD measurements:
:TYPE <name>	Select RTD parameters: PT385, PT3916, USER.
:TYPE?	Query RTD type.
:ALPHa <NRf>	Specify constant for USER type (0 to 0.01).
:ALPHa?	Query alpha.
:BETA <NRf>	Specify constant for USER type (0 to 1).
:BETA?	Query beta.
:DELTa <NRf>	Specify constant for USER type (0 to 5).
:DELTa?	Query delta.
:RZERo <NRf>	Specify constant for USER type (0 to 1000).
:RZERo?	Query rzero.
:TCouple	Path to configure TC measurements:
:TYPE <name>	Select thermocouple type: J, T, K, E, R, S, B.
:TYPE?	Query TC type.
:RJUNctionX	Path to configure reference junctions (X = 1 to 5).
:RSElect <name>	Select reference type: SIMulated, REAL.
:RSELect?	Query reference type.
:Simulated <n>	Specify simulated temperature.
:SIMulated?	Query simulated temperature.
:REAL	Command path to specify "real" reference junction.
:TCOefficient <n>	Specify TC
:TCOefficient?	Query TC
:OFFSet <n>	Specify voltage offset of 0°C.
:OFFSet?	Query voltage offset.
:ACQuire	Update reference temperature.
:SENSe2	
:TTL[1]	Path to read digital input port:
:DATA?	Query (read) the digital input port.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
:SOURce	
:TTL[1][:LEVel] <b>	Set digital output line #1 true (1 or ON) or false (0 or OFF).
:TTL[1][:LEVel]?	Query digital output line 1.
:TTL2[:LEVel] <b>	Set digital output line #2 true (1 or ON) or false (0 or OFF).
:TTL2[:LEVel]?	Query digital output line 2.
:TTL3[:LEVel] <b>	Set digital output line #3 true (1 or ON) or false (0 or OFF).
:TTL3[:LEVel]?	Query digital output line 3.
:TTL4[:LEVel] <b>	Set digital output line #4 true (1 or ON) or false (0 or OFF).
:TTL4[:LEVel]?	Query digital output line 4.
:STATus	
:MEASurement	Path to control measurement event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:QUEue	Path to access error queue:
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Read the disabled messages.
:CLEar	Clears all messages from Error Queue.
:SYSTem	
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.
:POSetup?	Query power-on setup.
:FRSWitch?	Query INPUTS switch (0 = rear, 1 = front).
:AZERo	Path to set up auto-zero.
:TYPE <name>	Select auto-zero mode: NORMal, SYNChronous.
:TYPE?	Query auto-zero mode (0 or 1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) auto-zero.
:STATe?	Query auto-zero (0 or 1).
:AMEThod <name>	Select reading acquisition method: BURSt, NORMal, ASTReam, SSTReam.
:AMEThod?	Query acquisition method.
:LSYNc	Path to control line synchronization of measurements.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) line sync.
:STATe?	Query line sync (0 or 1).
:CLEar	Clears messages from the Error Queue.
:TRACe|:DATA	Use :TRACe or :DATA as root command.
:CLEar [BUFFER,]	Clear readings from buffer.
:EGRoup [BUFFER,] <name>	Select element group: FULL, COMPact.
:EGRoup? [BUFFER,]	Query element group.
:FEED [BUFFER,]	Select source of readings: SENSe[1], CALCulate[1], NONE.
:PRETrigger	Path to configure pre-trigger storage mode.
:AMOunt	Path to specify number of pre-trigger readings.
[:PERCent] [BUFFER,] <n>	Specify as a % (0 to 100) of buffer.
[:PERCent]? [BUFFER,]	Query percentage.
:READings [BUFFER,] <n>	Specify as a number.
:READings/ [BUFFER,]	Query number of readings.
:SOURce [BUFFER,] <name>	Select pre-trigger source event: EXTernal, TLINk, BUS, MANual.
:SOURce? [BUFFER,]	Query pre-trigger source event.

Table J-2 (cont.)
Syntax of non-SCPI commands implemented by Model 2001

Command	Description
:ARM[;SEQuance[1]]	
[:LAYer[1]]	
:TCONfigure	
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINE <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:LAYer2	Path to program arm layer 2:
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:TCONfigure	Path to configure Triggers:
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.
:PROTocol?	Query protocol.
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:SSYNchronous	Path to configure semi-synchronous Trigger Link:
:LINE <NRf>	Select trigger line (1 to 6).
:LINE?	Query trigger line.
:UNIT	
:VOLTage	Path to configure ACV units.
:AC <name>	Select ACV measurement units: V, DB, DBM.
:DB	Path to set DB reference voltage.
:REFerence <n>	Specify reference in volts.
:REFerence?	Query DB reference.
:DBM	Path to set DBM reference impedance.
:IMPedance <n>	Specify reference impedance.
:IMPedance?	Query DBM reference impedance.
:AC?	Query ACV units.

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Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

- ❑ Intermittent
- ❑ IEEE failure
- ❑ Front panel operational
- ❑ Analog output follows display
- ❑ Obvious problem on power-up
- ❑ All ranges or functions are bad
- ❑ Particular range or function bad; specify _____
- ❑ Batteries and fuses are OK
- ❑ Checked all cables

Display or output (check one)

- ❑ Drifts
- ❑ Unstable
- ❑ Overload
- ❑ Unable to zero
- ❑ Will not read applied input

- ❑ Calibration only
- ❑ Data required
- ❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

Model 2001 Multimeter

Quick Reference Guide

KEITHLEY

Model 2001 Multimeter

Quick Reference Guide

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U.S.A.

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI)

states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The WARNING heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The CAUTION heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Introduction

This quick reference guide includes summary information on front panel and IEEE-488 operation for the Model 2001 Multimeter. For detailed information, consult the Model 2001 Operator's Manual, the Model 2001 Calibration Manual, and the Model 2001-SCAN Scanner Card Instruction Manual.

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Operation Summary

Default Configuration

The Model 2001 can save from one to ten user setups in memory, depending on the installed memory option. You can select one of the user setups as the power-on default, or have the instrument power up to either of the two factory defaults (optimized for "BENCH" or "GPIB" operation). Reset the instrument to "BENCH" defaults from the front panel by performing the following steps:

1. Press the MENU key to display the main menu:

   MAIN MENU
   SAVESETUP GPIB CALIBRATION ▶
   ◀ TEST LIMITS STATUS-MSG GENERAL

2. If the SAVESETUP option is not blinking, press the ◀ key until it is blinking and then press ENTER to view the setup menu:

   SETUP MENU
   SAVE RESTORE POWERON RESET

3. Select the RESET option and press ENTER to view the reset menu:

   RESET ORIGINAL DFLTS
   BENCH GPIB

4. Select the BENCH option and press ENTER. The following message is displayed:

   RESETTING INSTRUMENT
   ENTER to confirm; EXIT to abort

5. Press ENTER to confirm. The display will show DC voltage readings with autorange enabled.

Assuming the Model 2001 is set to primary address 16, the instrument can be reset and the reading displayed on the computer CRT from the IEEE-488 bus with the following code fragment:

```
100  OUTPUT 716;":syst:pres"
110  OUTPUT 716;":fetc?"
120  ENTER 716;A$
130  PRINT A$
```

Instrument Connections

Each measurement function has an appropriate connection scheme. Connections for all functions can be found in Section 3 of the Model 2001 Operator's Manual. The following steps summarize making DC voltage measurements with the Model 2001:

1. Select the front input jacks with the INPUTS button (outer position for front jacks, inner position for rear).

2. Using the set of supplied test leads, connect the Model 2001 to a DC voltage source (e.g., a battery) as shown in Figure 1.

3. Use the RANGE keys to select autoranging or a manual range. Pressing the AUTO range key toggles autoranging. You can select a different range with the ▲ RANGE and ▼ RANGE keys. The following code statement enables autoranging on the DCV function:

   ```
   100  OUTPUT 716;":volt:dc:rang:auto  on"
   ```

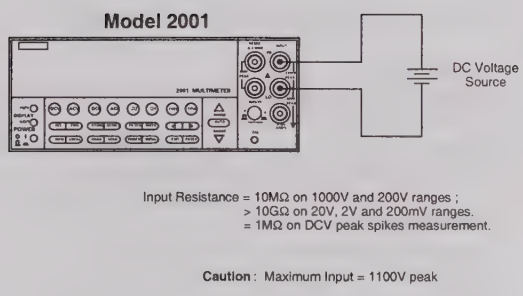
Model 2001
DC Voltage Source
Input Resistance = 10MΩ on 1000V and 200V ranges ;
> 10GΩ on 20V, 2V and 200mV ranges.
= 1MΩ on DCV peak spikes measurement.
Caution : Maximum Input = 1100V peak

Figure 1. Typical DC voltage connections

Changing the Configuration

Each measurement function and operation has the default settings that are listed in Table 18. For example, the default settings for DC voltage are as follows:

- Measurement speed (integration time) — Normal, 1 power line cycle.
- Digital filter — Advanced, 10 readings, 1% noise tolerance, moving average.
- Display resolution — 6.5 digits.

If these settings are not sufficient for your application, they can be changed through configuration menus. For example, to configure the DC voltage function to store high speed measurements, follow these steps:

1. Press CONFIG key and then the DCV key to view

the DCV configuration menu:

CONFIGURE DCV
SPEED FILTER RESOLUTION

2. Select SPEED from the menu, then press ENTER. The multimeter displays the following menu:

   DCV MEASUREMENT SPEED
   NORMAL FAST MEDIUM HIACCURACY ▶
   ◀ SET-SPEED-EXACTLY SET-BY-RESLN

3. Using the cursor keys, select the FAST option, then press ENTER. Since the resolution is set to AUTO, where it defaults to a value appropriate for the speed, it will be set to 4.5d automatically.

4. Press EXIT to return to the normal display.

To store readings in the instrument's data storage buffer, perform the following:

1. Press the STORE key. The following message is displayed:

   STORE 00100 READINGS
   Use ◀, ▶, ▲, ▼, ENTER, EXIT, or INFO

2. Use the cursor and RANGE keys to change the number of readings stored, or just press ENTER to start storing readings.

To recall the stored readings, perform the following:

1. Press RECALL to view the readings. The following message is displayed with the cursor on the least significant digit of the reading number:

+000.0000 mVDC
Rdg#+00000 @Time =+000.000000 sec

2. Use the RANGE keys to increment and decrement the reading number and scroll through the buffer.

3. The NEXT and PREV DISPLAY keys can be used while recalling readings to access additional buffer data, such as maximum and minimum readings.

The following code fragment configures the Model 2001 for high speed DC voltage readings, stores 100 readings, and sends the readings over the bus:

```
100  OUTPUT 716;":syst:pres"
110  OUTPUT 716;":volt:dc:nplc  0.01"
120  OUTPUT 716;":trac:clear"
130  OUTPUT 716;":trac:feed  calc"
140  OUTPUT 716;":trac:egr  full"
150  OUTPUT 716;":trac:poin  100"
160  OUTPUT 716;":trac:feed:cont  next"
170  OUTPUT 716;":trac:data?"
180  ENTER 716;A$
190  PRINT A$
```

Multiple Displays

Each measurement function has its own set of "multiple displays" shown on the bottom line of the front panel display. To scroll through the multiple displays available for the present function, repeatedly press and release the NEXT DISPLAY key. The same action with the PREVious DISPLAY key does a reverse scroll through the displays. To return to the default reading display, just press and hold either key.

Table 1. Multiple displays by function

Function	Next display
All	Bar graph Zero-centered bar graph Maximum and minimum values Relative and actual values Calculated and actual values (see Note 1) Limits bar graph (see Note 1) Adjacent channel readings (see Note 2)
DC voltage	DC volts, AC ripple voltage and frequency Positive peak spikes and highest value Negative peak spikes and lowest value Positive and negative peak spikes
AC voltage	AC RMS voltage, frequency, and crest factor AC RMS, average, and peak voltages
DC current	(none specific to function)
AC current	AC RMS (or average) current and frequency AC RMS and average current
2-wire resistance	Source current Voltage drop across DUT
4-wire resistance	Source current Voltage drop across DUT Lead resistance
Frequency	Period calculation Trigger level

Table 1. Multiple displays by function (cont.)

Function	Next display
Temperature	Celsius, Fahrenheit, and Kelvin units RTD resistance (or thermocouple voltage) Reference junction (thermocouples only)
Data storage buffer	Maximum and minimum values Average and standard deviation

Notes:
1. Multiple displays for calculated values and limits bar graph are not available for the frequency function.
2. The multiple display for adjacent channel readings is not available for the DC and AC current functions.

Menu Structures

The desired menu is displayed by pressing the appropriate key or sequence:

- CONFIG and then DCV (or ACV, DCI, ACI, Ω2, Ω4, FREQ, TEMP) — Shows the configuration menu for each measurement function.
- CONFIG and then NEXT DISPLAY (or PREV DISPLAY, REL, TRIG, STORE, FILTER, MATH, CHAN, SCAN) — Shows the configuration menu for the multiple displays and each measurement operation.
- MENU — The main menu accesses items for which there are not dedicated keys.

Once in a menu structure, place the cursor (◀ and ▶ keys) on the desired selection and press ENTER. Use the cursor keys, RANGE ▲ and RANGE ▼ keys to enter parameters. Use the EXIT key to back out of a menu structure and disable a menu.

Table 2. CONFIGURE DCV menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
ANALOG-FILTER	Enable (ON) or disable (OFF) analog filter.

Table 2. CONFIGURE DCV menu structure (cont.)

Menu item	Description
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.

Table 3. CONFIGURE ACV menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.

Table 3. CONFIGURE ACV menu structure (cont.)

Menu item	Description
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
UNITS	Display units menu:
VOLTS	Select volts.
dB	Select dB and set voltage reference level.
dBm	Select dBm and set reference impedance.
COUPLING	Coupling menu:
AC	Select AC coupled measurements.
AC+DC	Select DC coupled measurements.
AC-TYPE	Type of ACV measurement menu:
RMS	Select true RMS ACV.
AVERAGE	Select average ACV.
PEAK	Select peak ACV.
LOW-FREQ-RMS	Select low frequency (typically <50Hz) true RMS ACV.
POSITIVE-PEAK	Select positive DCV peak spikes measurements.
NEGATIVE-PEAK	Select negative DCV peak spikes measurements.

Table 4. CONFIGURE DCI menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
MEASUREMENT-MODE	Measurement mode menu:
NORMAL	Select normal current measurement (use AMPS terminals).
IN-CIRCUIT	Select in-circuit current measurement (use INPUT and SENSE terminals).

Table 5. CONFIGURE ACI menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
COUPLING	Coupling menu:
AC	Select AC coupled measurements.
AC+DC	Select DC coupled measurements.
AC-TYPE	Type of ACI measurement menu:
RMS	Select true RMS ACI.
AVERAGE	Select average ACI.

Table 6. CONFIGURE OHMS-2W menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
OFFSETCOMP	Enable/disable offset compensation (20Ω-20kΩ ranges).
MAXAUTORANGE	Set upper limit for autoranging of 2-wire resistance.
1GΩ, 200MΩ, 20MΩ, 2MΩ, 200kΩ, 20kΩ	Select a specific range.

Table 7. CONFIGURE OHMS-4W menu structure

Menu item	Description
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Program a simple average filter (1-100 readings).
ADVANCED	Program a simple average filter (1-100 readings) with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.
RESOLUTION	Display resolution menu:
AUTO	Default to resolution appropriate for integration time.
3.5d, 4.5d, 5.5d, 6.5d, 7.5d	Select a specific resolution.
OFFSETCOMP	Enable/disable offset compensation (20Ω-20kΩ ranges).
MAXAUTORANGE	Set upper limit for autoranging of 4-wire resistance.
200kΩ, 20kΩ, 2kΩ	Select a specific range.

Table 8. CONFIGURE FREQUENCY menu structure

Menu item	Description
MAX-SIGNAL-LEVEL	Display maximum signal level menu:
1V, 10V, 100V, 1000V, TTL	Select maximum voltage level for voltage inputs.
1mA, 10mA, 100mA, 1A	Select maximum current level for current inputs.
RESOLUTION	Display resolution menu:
4-DIGITS, 5-DIGITS	Select a specific resolution.
INPUT-TERMINALS	Input terminals for frequency measurements menu:
VOLTAGE	Select INPUT HI and INPUT LO terminals.
CURRENT	Select AMPS and INPUT LO terminals.
COUPLING	Coupling menu:
AC	Select AC coupled measurements.
AC+DC	Select DC coupled measurements.

Note: The maximum signal level menu is coupled to the input terminals menu, i.e., voltage levels are shown if voltage is the selected input.

Table 9. CONFIG TEMPERATURE menu structure

Menu item	Description
SENSOR	Sensor type menu:
4-WIRE-RTD	4-wire RTD type menu:
PT385	Select a PT385 type.
PT3916	Select a PT3916 type.
USER-RTD	Select desired R-zero, alpha, beta, and delta.
RTD	2-wire RTD type menu:
PT385	Select a PT385 type.
PT3916	Select a PT3916 type.
USER-RTD	Select desired R-zero, alpha, beta, and delta.
SENSOR	
THERMOCOUPLE	Thermocouple setup menu:
THERMOCOUPLE-TYPE	Select desired thermocouple type (J, K, T, E, R, S, B).
REF-JUNCTIONS	Configure reference junction menu (JN1 thru JN5):
CONFIGURE	Configure simulated or real junction.
ACQUIRE-REF-TEMP	Acquire reference temperature.
UNITS	Temperature units menu:
DEG-C, DEG-F, K	Select desired temperature units.
SPEED	Measurement speed (integration time) menu:
NORMAL	Select 1 PLC (power line cycle, 16.67msec for 60Hz, 20msec for 50Hz and 400Hz).
FAST	Select 0.01 PLC.
MEDIUM	Select 0.1 PLC.
HIACCURACY	Select 10 PLC.
SET-SPEED-EXACTLY	Set integration time in PLC (0.01-10).
SET-BY-RSLN	Default to setting appropriate for resolution.

Table 9. CONFIG TEMPERATURE menu structure (cont.)

Menu item	Description
FILTER	Digital filter menu:
AUTO	Default to filter appropriate for integration time.
AVERAGING	Select simple average filter (1-100 readings).
AVERAGING-MODE	Select moving average or repeating average mode.
RESLN	Display resolution menu:
AUTO	Default to resolution appropriate for sensor.
1°, 0.1°, 0.01°, 0.001°	Select a specific resolution.

Table 10. CONFIGURE TRIGGER menu structure

Menu item	Description
MEASURE	Measure layer menu:
SOURCE	Select measure source:
IMMEDIATE	Use to make measurements immediately.
EXTERNAL	Use external triggers to control measuring.
MANUAL	Use TRIG key to control measuring.
GPIB	Use bus triggers to control measuring.
TRIGLINK	Use Trigger Link triggers to control measuring. Enter Trigger Link mode and lines.
TIMER	Use a timer to control measuring and enter interval between triggers (0.001-999999.999sec).
HOLD	Use to hold up the measurement in the measure layer.
DELAY	Use to delay measurement in the measure layer (0.001-999999.999sec).
COUNT	Define number of measurements to make:
INFINITE	Repeat measuring indefinitely.
ENTER-CHAN-COUNT	Count = use defined value (1-99999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.

Table 10. CONFIGURE TRIGGER menu structure (cont.)

Menu item	Description
SCAN	Scan layer menu:
SOURCE	Select scan source:
IMMEDIATE	Use to pass operation immediately into the measure layer.
EXTERNAL	Use external triggers to control scanning.
MANUAL	Use TRIG key to control scanning.
GPIB	Use bus triggers to control scanning.
TRIGLINK	Use Trigger Link triggers to control scanning. Enter Trigger Link lines.
TIMER	Use a timer to control scanning and enter interval between scans (0.001-999999.999sec).
HOLD	Use to hold up the measurement in the scan layer.
DELAY	Use to delay scan in the scan layer (0.001-999999.999sec).
COUNT	Define number of scans to be performed:
INFINITE	Repeat scanning indefinitely.
ENTER-SCAN-COUNT	Count = user defined value (1-99999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.

Table 10. CONFIGURE TRIGGER menu structure (cont.)

Menu item	Description
ARM	Arm layer menu:
SOURCE	Select arm source:
IMMEDIATE	Use to arm meter immediately and pass operation into the scan layer.
EXTERNAL	Use external triggers to arm meter.
MANUAL	Use TRIG key to arm meter.
GPIB	Use bus triggers to arm meter.
TRIGLINK	Use Trigger Link triggers to arm meter. Enter Trigger Link lines.
HOLD	Use to hold up the measurement in the arm layer.
COUNT	Define number of times to arm meter:
INFINITE	Continuously re-arm meter.
ENTER-ARM-COUNT	User defined count value (1-99999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
HALT	Use to halt triggers. Press TRIG key to resume triggering.

Table 11. CONFIG DATA STORE menu structure

Menu item	Description
BURST-MODE	Acquire 4.5-digit readings at 2000 readings/sec and store in buffer.
DATA-GROUP	Select data types to store in buffer.
FULL	Store reading, units, channel#, reading#, time-stamp, and status (overflow).
COMPACT	Store reading, units, reading#, and status (overflow).
CONTROL	Select type of buffer control.
FILL-AND-STOP	Fill buffer with readings and stop.
PRETRIGGER	Wait for pretrigger event; store before and after readings.
PERCENTAGE	Enter percentage of stored readings before trigger.
READING-COUNT	Enter count of stored readings before trigger.
EVENT	Select source for pretrigger event.
CONTINUOUS	Store readings in buffer continuously.
NEVER	Readings are not stored.
CLEAR-ALL	Clear all stored readings and buffer statistics.
COUNT	Select buffer size.
ENTER-COUNT	Enter number of readings to store.
USE-TRIGGER-MODEL	Use (finite) measure count from trigger model.
FEED	Select type of reading to store.
AFTER-CALC	Store readings after percent or mX+b calculation.
BEFORE-CALC	Store readings before percent or mX+b calculation.

Table 12. CONFIG FILTER menu structure

Menu item	Description
AUTO	Default to filter appropriate for measurement function and type.
AVERAGING	Program simple average filter (1-100 readings).
ADVANCED	Program simple average filter (1-100 readings), with a noise tolerance window (0-100% of range).
AVERAGING-MODE	Select moving average or repeating average mode.

Table 13. CONFIGURE MATH menu structure

Menu item	Description
NONE	Select no calculation when MATH key is pressed.
mX+b	Select mX+b calculation and enter constants.
PERCENT	Select percent calculation and enter target (reference) value.

Table 14. CHANNEL SELECTION menu structure

Menu item	Description
CLOSE-CHANNEL ENTER CHAN#01 (1-10)	Close channel menu: Use cursor, range, and ENTER keys.
OPEN-ALL-CHANNELS	Press ENTER to open closed channel(s).

Table 15. CONFIGURE CHANNELS menu structure

Menu item	Description
INTERNAL-CHANS	Defines internal functions:
SET INTERNAL CHANS 1=DCV 2=DCV 3=DCV 4=DCV 5=DCV	Use range and cursor keys to select channels and functions.
EXTERNAL INPUTS	Sets number of external channels and functions:
# EXTERNAL INPUTS=80	# of external channels (1-80).
DEFAULT	Selects default function for all external channels.
CHOOSE-FUNCTIONS	Use to select channel functions.
SELECT CHAN=01	Select channel using range and cursor keys.
CHANNEL #01 FUNCTION	Select function using cursor keys.
SAVE-ALT-FCN	Stores present function as alternate.
RESTORE-ALT-FUNCTION	Restores saved alternate function.

Table 16. SCAN OPERATION menu structure

Menu item	Description
INTERNAL	Enables internal scanning.
EXTERNAL	Enables external scanning.
RATIO	Enables ratio mode (internal).
MEASURE	Selects measure channel.
REFERENCE	Selects reference channel.
FUNCTION	Selects ratio function.
DELTA	Enables delta mode (internal).
MEASURE	Selects measure channel.
REFERENCE	Selects reference channel.
FUNCTION	Selects delta function.

Table 17. Main menu structure

Menu item	Description
SAVESETUP	Setup menu:
SAVE	Save setup at a memory location (up to 1, 5, or 10).
RESTORE	Return 2001 to setup stored at a memory location (up to 1, 5, or 10).
POWERON	Power-on Menu:
BENCH	Power on to bench default setup conditions.
GPIB	Power on to GPIB default setup conditions.
USER-SETUP-NUMBER	Power on to setup stored at a memory location (up to 1, 5, or 10).
RESET	Reset Menu:
BENCH	Return 2001 to bench default setup.
GPIB	Return 2001 to GPIB default setup.

Table 17. Main menu structure (cont.)

Menu item	Description
GPIB	GPIB/Printer Setup menu:
ADDRESSABLE	Check/change IEEE-488 bus address (0-30).
TALK-ONLY	GPIB/Printer Talk-only mode menu:
FEED	GPIB Output Feed menu:
AFTER-CALC	Specify reading after math operation.
BEFORE-CALC	Specify reading before math operation.
NONE	Specify no readings.
INTERFACE	Select printer interface.
IEEE-488	Specify IEEE-488 printer.
CENTRONICS	Specify Centronics parallel printer.
INTERVAL	Specify printing interval (every reading to 1 out of 9999).
FORMFEED	Formfeeds menu:
CONTROL	Enable/disable page breaks.
SET-PAGE-SETUP	Set number line between form feeds (1-255).
ELEMENTS	Select GPIB data elements (reading, units, reading number, channel number, timestamp, status).
STATUS	Display IEEE-488 bus status byte.
CALIBRATION	Calibration menu:
COMPREHENSIVE	Perform DC and AC calibration.
AC-ONLY-CAL	Perform AC calibration only (open-circuit).
CALIBRATION-DATES	Check/change calibration date.
TEST	Self-test menu:
BUILT-IN-TEST	Test analog and digital boards.
AUTOMATIC	Run all tests automatically.
MANUAL	Select tests to run.
DIAGNOSTICS	Factory diagnostic tests.
FRONT-PANEL-TESTS	Test display board.
KEYS	Verify operation of front panel keys.
DISPLAY-PATTERNS	Verify operation of display.

Table 17. Main menu structure (cont.)

Menu item	Description
LIMITS	Limits menu:
LIMIT-SET-1	Limit-Set-1 menu:
CONTROL	Enable/disable limit set #1.
LOLIM1	Set value of low limit #1.
HILIM1	Set value of high limit #1.
LIMIT-SET-2	Limit-Set-2 menu:
CONTROL	Enable/disable limit set #2.
LOLIM2	Set value of low limit #2.
HILIM2	Set value of high limit #2.
STROBE-CONTROL	Enable/disable limit strobe signal of digital output #4 when trigger occurs.
PASS-PATTERN	Specify patterns on digital outputs to signify limits pass.
STATUS-MSG	Enable/disable status message mode.
GENERAL	General menu:
DIGITAL-I/O	Digital I/O menu:
OUTPUT-STATE	Check/change states of digital output lines.
OUTPUT-SENSE	Check/change sense of digital output lines.
INPUT	Read digital input line.
SERIAL#	Display serial number, memory option, SCPI version, and firmware revisions.
AUTOZERO	Disable or enable normal (after every reading) or synchronous (every 200ms) autozero mode.
GENERAL	
LINE-SYNC	Enable/disable line synchronization of measurements.
DECIMAL	Select period or comma for display of decimal point.

Default Conditions

Table 18. Factory default conditions

Function or operation	Bench default	GPIB default
AC current:		
AC-type	RMS	RMS
Coupling	AC	AC
Filter	Off	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	5%	5%
Filter mode	Moving	Repeat
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (5.5d)	Auto (5.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
AC voltage:		
AC-type	RMS	RMS
Peak spikes window	0.1sec	0.1sec
Coupling	AC	AC
Filter	Off	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	5%	5%
Filter mode	Moving	Repeat
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (5.5d)	Auto (5.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
Units	Volts	Volts
dB reference	1V	1V
dBm reference	75Ω	75Ω
Autozero	On (Normal)	On (Normal)

Table 18. Factory default conditions (cont.)

Function or operation	Bench default	GPIB default
Buffer:		
Burst mode	No effect	No effect
Control	No effect	No effect
Count	No effect	No effect
Data group	No effect	No effect
Feed	No effect	No effect
DC current:		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Measurement mode	Normal	Normal
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
DC voltage:		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Range	Auto	Auto
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
Digital I/O:		
Output states	No effect	No effect
Output sense	No effect	No effect
Frequency:		
Coupling	AC	AC
Maximum signal level:		
Function	Voltage	Voltage
Voltage level	10V	10V
Current level	1mA	1mA

Table 18. Factory default conditions (cont.)

Function or operation	Bench default	GPIB default
Frequency:		
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (5d)	Auto (5d)
Terminals	Voltage	Voltage
Trigger level	0.0	0.0
Function	DCV	DCV
Limits:		
Limit set #1	Off	Off
Low limit #1	-1.0	-1.0
Low limit #1 action	0	0
High limit #1	1.0	1.0
High limit #1 action	0	0
Limit set #2	Off	Off
Low limit #2	-1.0	-1.0
Low limit #2 action	0	0
High limit #2	1.0	1.0
High limit #2 action	0	0
Strobe control	Off	Off
Pass pattern	0	0
Line synchronization	Off	Off
Math	Off	Off
Function	Percent	Percent
Reference for percent	1.0	1.0
Scale factor for mX+b	1.0	1.0
Offset for mX+b	0.0	0.0
Resistance (2-wire):		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Offset compensation	Off	Off
Range	Auto	Auto
Maximum autorange	1GΩ	1GΩ
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)

Table 18. Factory default conditions (cont.)

Function or operation	Bench default	GPIB default
Resistance (4-wire):		
Filter	On	Off
Auto	On	Off
Averaging	Off	Off
Readings	10	10
Advanced	On	On
Readings	10	10
Noise tolerance level	1%	1%
Filter mode	Moving	Repeat
Offset compensation	Off	Off
Range	Auto	Auto
Maximum autorange	200kΩ	200kΩ
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (6.5d)	Auto (6.5d)
Speed	Normal (1 PLC)	Normal (1 PLC)
Scanning:		
Channels	No effect	No effect
Scan list:		
Internal list	No channels	No channels
External list	No channels	No channels
Function	DC voltage	DC voltage
Scan operation	None	None
Ratio:		
Reference channel	5	5
Measure channel	10	10
Function	DC voltage	DC voltage
Delta:		
Reference channel	5	5
Measure channel	10	10
Function	DC voltage	DC voltage

Table 18. Factory default conditions (cont.)

Function or operation	Bench default	GPIB default
Temperature:		
Filter	On	Off
Auto	On	Off
Averaging	On	On
Readings	10	10
Filter mode	Moving	Repeat
Relative	Off	Off
Value	0.0	0.0
Resolution	Auto (0.01°C)	Auto (0.01°C)
RTDs:		
Type	PT385	PT385
Resistance at 0°C	100Ω	100Ω
Alpha	0.00385	0.00385
Beta	0.111	0.111
Delta	1.507	1.507
Temperature:		
Sensor	4-wire RTD	4-wire RTD
Speed	Normal (1 PLC)	Normal (1 PLC)
Thermocouples:		
Type	J	J
Reference junction	Simulated	Simulated
Default temperature	23°C	23°C
Real junction temp. coefficient	10mV/°C	10mV/°C
Offset	0mV @ 0°C	0mV @ 0°C
Units	°C	°C

Table 18. Factory default conditions (cont.)

Function or operation	Bench default	GPIB default
Triggers:	Armed	Idled
Arm layer:		
Source	Immediate	Immediate
Triglink input	Line 2	Line 2
Triglink output	Line 1	Line 1
Count	1	1
Control	Acceptor	Acceptor
Scan layer:		
Source	Immediate	Immediate
Triglink input	Line 2	Line 2
Triglink output	Line 1	Line 1
Delay	0	0
Count	Infinite	1
Control	Acceptor	Acceptor
Measure layer:		
Source	Immediate	Immediate
Triglink mode	Asynchronous	Asynchronous
Triglink input	Line 2	Line 2
Triglink output	Line 1	Line 1
Timer	0.1sec	0.1sec
Delay	0	0
Count	Infinite	1
Control	Acceptor	Acceptor

*Table 19. *RST and :SYSTem:PRESet*

Command	*RST	:SYSTem:PRESet
IEEE 488.2 common commands		
All commands	[unaffected]	[unaffected]
SCPI signal oriented commands		
:CONFigure	"VOLT:DC"	"VOLT:DC"
Calculate 1 subsystem		
:CALCulate1		
:STATe	0 (OFF)	0 (OFF)
:FORMat	PERCent	PERCent
:MMFactor	1.0	1.0
:MBFactor	0.0	0.0
:PERCent	1.0	1.0
Calculate 2 subsystem		
:CALCulate2		
:STATe	0 (OFF)	0 (OFF)
:FORMat	NONE	NONE
Calculate 3 subsystem		
:CALCulate3		
:LIM1		
:STATe	0 (OFF)	0 (OFF)
:UPPer		
:DATA	1.0	1.0
:SOURce	0	0
:LOWer		
:DATA	-1.0	-1.0
:SOURce	0	0
:CLEar		
:AUTO	1 (ON)	1 (ON)
:LIM2		
:STATe	0 (OFF)	0 (OFF)
:UPPer		
:DATA	1.0	1.0
:SOURce	0	0
:LOWer		
:DATA	-1.0	-1.0
:SOURce	0	0
:CLEar		
:AUTO	1 (ON)	1 (ON)

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
:CALCulate3		
:BSTRobe		
:STATe	0 (OFF)	0 (OFF)
:PASS		
:SOURce	0	0
Calibration subsystem		
All commands	[unaffected]	[unaffected]
Display subsystem		
:DISPlay		
:SMESsage	0 (OFF)	0 (OFF)
:WINDow1		
:TEXT		
:STATe	[unaffected]	[unaffected]
:DATA	[unaffected]	[unaffected]
:WINDow2		
:TEXT		
:STATe	[unaffected]	[unaffected]
:DATA	[unaffected]	[unaffected]
:ENABle	[unaffected]	[unaffected]
Format subsystem		
:FORMat		
:DATA	ASCII	ASCII
:BORDer	SWAPped	SWAPped
:ELEMents	READing	all
Output commands		
All commands	[unaffected]	[unaffected]
Route subsystem		
:ROUTe		
:CLOSe	[unaffected]	[unaffected]
:OPEN	[unaffected]	[unaffected]
:SCAN		
:INTernal	empty	empty
:FUNCtion	all "VOLT:DC"	all "VOLT:DC"
:EXTernal	empty	empty
:FUNCtion	all "VOLT:DC"	all "VOLT:DC"

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
:ROUTe		
:SCAN		
:RATio		
:RCHannel	5	5
:MCHannel	10	10
:FUNCtion	"VOLT:DC"	"VOLT:DC"
:DELTa		
:RCHannel	5	5
:MCHannel	10	10
:FUNCtion	"VOLT:DC"	"VOLT:DC"
:LSELect	NONE	NONE
Sense commands		
:SENSe1		
:FUNCtion	"VOLT:DC"	"VOLT:DC"
AC current commands		
:SENSe1		
:CURRent		
:AC		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:COUPling	AC	AC
:RANGe		
:UPPer	2.1	2.1
:AUTO	1 (ON)	1 (ON)
:ULIMit	2.1	2.1
:LLIMit	2.0E-4	2.0E-4
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	6	6
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	0 (OFF)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	5	5
:DETector		
:FUNCtion	RMS	RMS

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
DC current commands		
:SENSe1		
:CURRent		
:DC		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:RANGe		
:UPPer	2.1	2.1
:AUTO	1 (ON)	1 (ON)
:ULIMit	2.1	2.1
:LLIMit	2.0E-4	2.0E-4
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOV
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	1	1
:METHod	NORMal	NORMal
AC voltage commands		
:SENSe1		
:VOLTage		
:AC		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:COUPling	AC	AC
:RANGe		
:UPPer	775	775
:AUTO	1 (ON)	1 (ON)
:ULIMit	775	775
:LLIMit	2	2
:REFerence	0.0	0 0
:STATe	0 (OFF)	0 (OFF)

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
:SENSe1		
:VOLTage		
:AC		
:DIGits	6	6
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	0 (OFF)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	5	5
:DETector	RMS	RMS
:FUNCtion	0.1	0.1
DC voltage commands		
:SENSe1:		
:VOLTage		
:DC		
:APERture	1/LineFreq	1/LineFreq
:NPLCycle	1	1
:AUTO	0 (OFF)	0 (OFF)
:RANGe		
:UPPer	1100	1100
:AUTO	1 (ON)	1 (ON)
:ULIMit	1100	1100
:LLIMit	.2	.2
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	0 (OFF)
:NTOLerance	1	1

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
Frequency commands		
:SENSe1		
:FREQuency		
:COUPling	AC	AC
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	5	5
:THReshold		
:VOLTage		
:LEVel	0	0
:RANGe	10	10
:CURRent		
:LEVel	0	0
:RANGe	1.0E-3	1.0E-3
:SOURce	VOLTage	VOLTage
2-wire resistance commands		
:SENSe1		
:RESistance		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:RANGe		
:UPPer	1.1E+9	1.1E+9
:AUTO	1 (ON)	1 (ON)
:ULIMit	1.1E+9	1.1E+9
:LLIMit	20	20
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:OCOMpensated	0 (OFF)	0 (OFF)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	1	1

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
4-wire resistance commands		
:SENSe1		
:FRESistance		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:RANGe		
:UPPer	2.1E+5	2.1E+5
:AUTO	1 (ON)	1 (ON)
:ULIMit	2.1E+5	2.1E+5
:LLIMit	20	20
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	7	7
:AUTO	1 (ON)	1 (ON)
:OCOMpensated	0 (OFF)	0 (OFF)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:ADVanced		
:STATe	1 (ON)	1 (ON)
:NTOLerance	1	1
Temperature commands		
:SENSe1		
:TEMPerature		
:APERture	1/LineFreq	1/LineFreq
:AUTO	0 (OFF)	0 (OFF)
:NPLCycles	1	1
:AUTO	0 (OFF)	0 (OFF)
:REFerence	0.0	0.0
:STATe	0 (OFF)	0 (OFF)
:DIGits	6	6
:AUTO	1 (ON)	1 (ON)
:AVERage		
:STATe	0 (OFF)	1 (ON)
:AUTO	0 (OFF)	1 (ON)
:COUNt	10	10
:TCONtrol	REPeat	MOVing
:RJUNction1		
:RSELect	SIMulated	SIMulated

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
:SENSe1		
:TEMPerature		
:RJUNction1		
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction2		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction3		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction4		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:RJUNction5		
:RSELect	SIMulated	SIMulated
:SIMulated	23(°C)	23(°C)
:REAL		
:TCOefficient	0.01	0.01
:OFFSet	0.01	0.01
:TRANsducer	FRTD	FRTD
:RTD		
:TYPE	PT385	PT385
:ALPHa	0.00385	0.00385
:BETA	0.111	0.111
:DELTa	1.507	1.507
:RZERo	100.0	100.0
:TCouple		
:TYPE	J	J
Source subsystem		
All commands	[unaffected]	[unaffected]

*Table 19. *RST and :SYSTem:PRESet (cont.)*

Command	*RST	:SYSTem:PRESet
System subsystem		
:SYSTem		
:KEY	[unaffected]	[unaffected]
:AZERo		
:STATe	1 (ON)	1 (ON)
:TYPE	NORMal	NORMal
:LSYNc		
:STATe	0 (OFF)	0 (OFF)
:POSetup	[unaffected]	[unaffected]
:AMEThod	NORMal	NORMal
:FETCh		
:FORMat	[unaffected]	[unaffected]
Trigger subsystem		
:INITiate		
:CONTinuous	0 (OFF)	1 (ON)
:ARM:SEQuence1		
:LAYer1		
:COUNt	1	1
:SOURce	IMMediate	IMMediate
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	2	2
:OLINe	1	1
:LAYer2		
:COUNt	1	INF
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.1	0.1
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	2	2
:OLINe	1	1
:TRIGger		
:SEQuence1		
:COUNt	1	INF
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.1	0.1
:TCONfigure		
:PROTcol	ASYNchronous	ASYNchronous
:DIRection	ACCeptor	ACCeptor

Table 19. *RST and :SYSTem:PRESet (cont.)

Command	*RST	:SYSTem:PRESet
:TRIGger		
:SEQuence1		
:TCONfigure		
:ASYNchronous		
:ILINe	2	2
:OLINe	1	1
:SSYNchronous		
:LINE	1	1
Status subsystem		
All commands	[unaffected]	[unaffected]
Trace subsystem		
All commands	[unaffected]	[unaffected]
Unit commands		
:UNIT		
:TEMPerature	C	C
:VOLTage		
:AC	V	V
:DB		
:REFerence	1	1
:DBM		
:IMPedance	75	75

Error and Status Messages

Table 20. Error and status messages

Number	Description	Event
+900	"Internal System Error"	EE
+611	"Questionable Temperature"	SE
+610	"Questionable Calibration"	SE
+515	"Calibration dates lost"	EE
+514	"DC calibration data lost"	EE
+513	"AC calibration data lost"	EE
+512	"Power-on state lost"	EE
+511	"GPIB address lost"	EE
+510	"Reading buffer data lost"	EE
+444 to +350	Calibration Errors (see Calibration Manual)	EE
+312	"Buffer Pretriggered"	SE
+310	"Buffer full"	SE
+309	"Buffer half full"	SE
+308	"Buffer Available"	SE
+306	"Reading Available"	SE
+305	"High limit 2 event"	SE
+304	"Low limit 2 event"	SE
+303	"High limit 1 event"	SE
+302	"Low limit 1 event"	SE
+301	"Reading overflow"	SE
+174	"Re-entering the idle layer"	SE
+173	"Waiting in arm layer 2"	SE
+172	"Waiting in arm layer 1"	SE
+171	"Waiting in trigger layer"	SE
+161	"Program running"	SE
+126	"Device calculating"	SE
+125	"Device measuring"	SE
+124	"Device sweeping"	SE
+123	"Device ranging"	SE
+122	"Device settling"	SE
+121	"Device calibrating"	SE
+101	"Operation Complete"	SE
+000	"No Error"	SE

Table 20. Error and status messages (cont.)

Number	Description	Event
SE = Status event EE = Error event		
-100	"Command Error"	EE
-101	"Invalid Character"	EE
-102	"Syntax Error"	EE
-103	"Invalid Separator"	EE
-104	"Data Type Error"	EE
-105	"GET not allowed"	EE
-108	"Parameter not allowed"	EE
-109	"Missing Parameter"	EE
-110	"Command Header Error"	EE
-111	"Command Header Separator Error"	EE
-112	"Program mnemonic too long"	EE
-113	"Undefined header"	EE
-114	"Header suffix out of range"	EE
-120	"Numeric data error"	EE
-121	"Invalid character in number"	EE
-123	"Exponent too large"	EE
-124	"Too many digits in number"	EE
-128	"Numeric data not allowed"	EE
-140	"Character data error"	EE
-141	"Invalid character data"	EE
-144	"Character data too long"	EE
-148	"Character data not allowed"	EE
-150	"String data error"	EE
-151	"Invalid string data"	EE
-154	"String too long"	EE
-158	"String data not allowed"	EE
-160	"Block data error"	EE
-161	"Invalid block data"	EE
-168	"Block data not allowed"	EE
-170	"Expression error"	EE
-171	"Invalid expression"	EE
-178	"Expression data not allowed"	EE
-200	"Execution error"	EE
-201	"Invalid while in local"	EE
-202	"Settings lost due to rtl" (return to local)	EE
SE = Status event EE = Error event		

Table 20. Error and status messages (cont.)

Number	Description	Event
-210	"Trigger error"	EE
-211	"Trigger ignored"	EE
-212	"Arm ignored"	EE
-213	"Init ignored"	EE
-214	"Trigger deadlock"	EE
-215	"Arm deadlock"	EE
-220	"Parameter Error"	EE
-221	"Settings conflict"	EE
-222	"Parameter data out of range"	EE
-223	"Too much data"	EE
-224	"Illegal parameter value"	EE
-230	"Data corrupt or stale"	EE
-241	"Hardware missing"	EE
-260	"Expression Error"	EE
-314	"Save/recall memory lost"	EE
-330	"Self Test failed"	EE
-350	"Queue overflow"	EE
-410	"Query interrupted"	EE
-420	"Query unterminated"	EE
-430	"Query deadlocked"	EE
-440	"Query unterminated after indefinite response"	EE

SE = Status event
EE = Error event

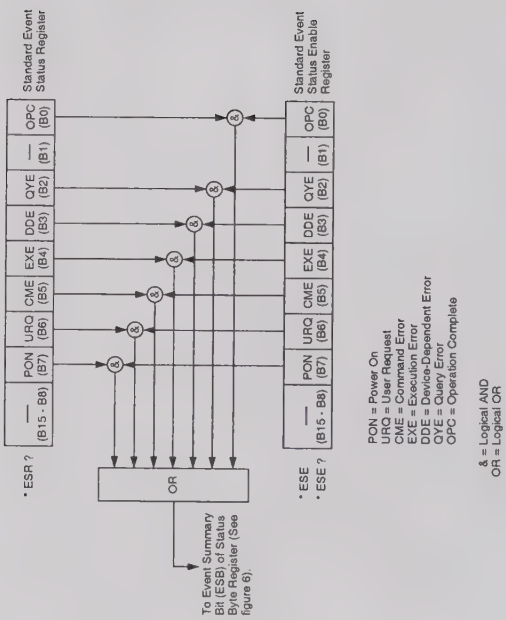

Figure 2. Standard event status

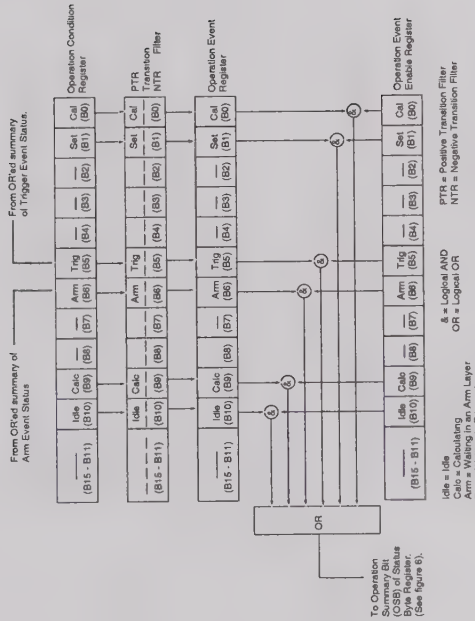

Figure 3. Operation event status

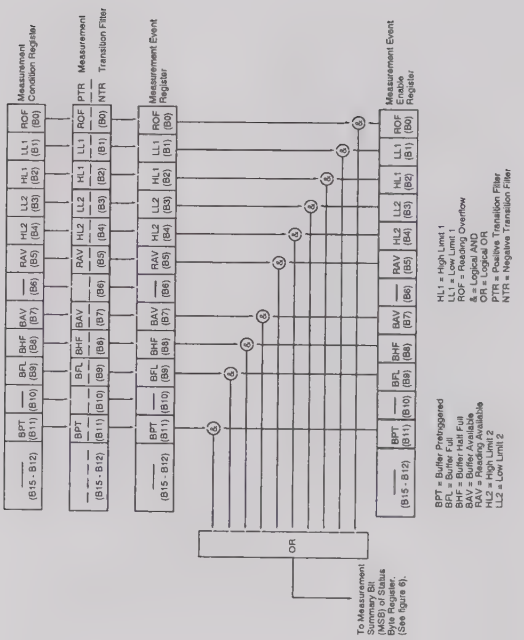
Measurement Condition Register
Measurement Transition Filter
Measurement Event Register
Measurement Event Enable Register
OR
To Measurement Summary Bit (MSB) of Status Byte Register (See figure 6).
BPT = Buffer Pretriggered
BFL = Buffer Full
BHF = Buffer Half Full
BAV = Buffer Available
RAV = Reading Available
HL2 = High Limit 2
LL2 = Low Limit 2
HL1 = High Limit 1
LL1 = Low Limit 1
ROF = Register Overflow
& = Logical AND
OR = Logical OR
PTR = Positive Transition Filter
NTR = Negative Transition Filter

Figure 4. Measurement event status

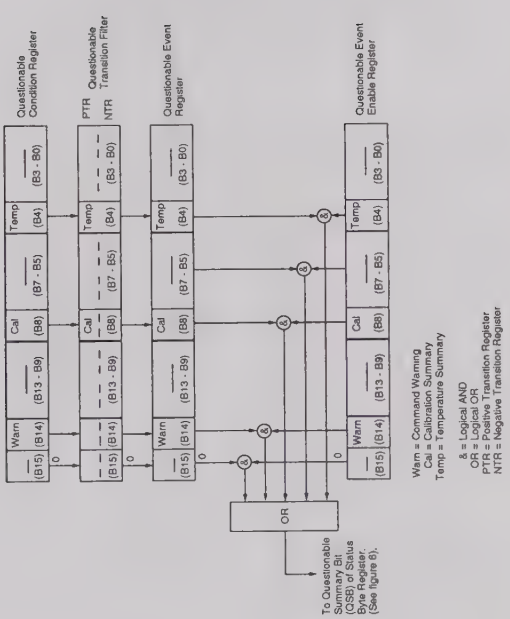

Figure 5. Questionable event status

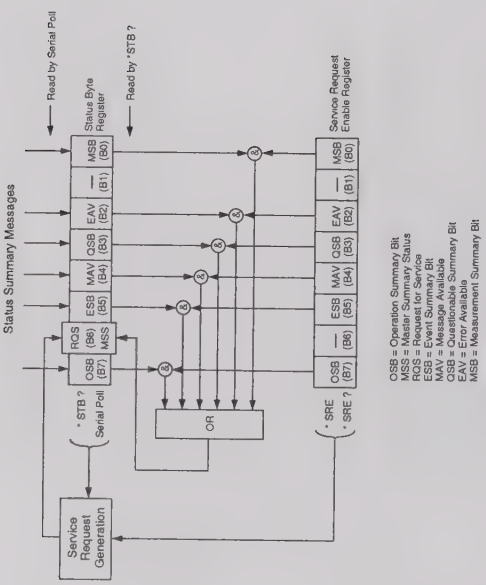

Figure 6. Status byte and service request (SRQ)

IEEE-488.2 Common Commands and Queries

Table 21. IEEE-488.2 common commands and queries

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers, and Error Queue.
*ESE <NRf>	Event Enable command	Sets Standard Event Enable Register.
*ESE?	Event Enable query	Reads Standard Event Enable Register.
*ESR?	Event status register query	Reads Standard Event Status Register and clears it.
*IDN?	Identification query	Reads ID information of instrument.
*OPC	Operation complete command	Sets the OPC bit in the Standard Event Status Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII "1" into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Reads ID code of options present (memory, scanner).
*RCL <NRf>	Recall command	Returns the 2001 to the setup configuration stored in the designated memory location.
*RST	Reset command	Returns the 2001 to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.
*SRE <NRf>	Service request enable command	Sets Service Request Enable Register.

Table 21. IEEE-488.2 common commands and queries (cont.)

Mnemonic	Name	Description
*SRE?	Service request enable query	Reads Service Request Enable Register.
*STB?	Read status byte query	Reads Status Byte Register.
*TRG	Trigger command	Issues a bus trigger.
*TST?	Self-test query	Performs a checksum test on ROM and return the results.
*WAI	Wait-to-continue command	Wait until all previous commands are executed.

SCPI Command Subsystems

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.

Table 22. Signal oriented measurement commands

Command	Description
:FETCh?	Requests the latest reading (SCPI) or a fresh reading (FRESh).
:CONFigure:<function>	Places the 2001 in a "one-shot" measurement mode for the specified function.
:READ?	Performs an :ABORt, :INITiate, and a FETCh?.
:MEASure[:<function>]?	Performs an :ABORt, :CONFigure :<function>, and a :READ?.

Table 23. Calculate command summary

Command	Description
:CALCulate[1]	Subsystem to control CALC 1:
:FORMat <name>	Select math format: MXB, PERCent, NONE.
:FORMat?	Query math format.
:KMATh	Path to configure math calculations:
:MMFactor <NRf>	Specify "m" for mX+b (-9.999999e20 to +9.999999e20).
:MMFactor?	Query "m" factor.
:MBFactor <NRf>	Specify "b" for mX+b (-9.999999e30 to +9.999999e30).

Table 23. Calculate command summary (cont.)

Command	Description
:CALCulate[1]	
:KMATh	
:MBFactor?	Query "b" factor.
:PERCent <NRf>	Set PERCENT value (-9.999999e35 to +9.999999e35).
:PERCent?	Query PERCENT.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.
:STATe?	Query state of math function.
:DATA?	Read math result of CALC 1.
:IMMediate	Recalculate input data.
:CALCulate2	Subsystem to control CALC 2:
:FORMat <name>	Select math format: MEAN, SDEViation, MAXimum, MINimum, PKPK, NONE.
:FORMat?	Query math format.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) calculation.
:STATe?	Query state of math function.
:IMMediate	Recalculate raw input data in buffer.
:DATA?	Read math result of CALC 2.
:CALCulate3	Subsystem to control CALC 3 (limit tests):
:LIMit[1]	Path to control LIMIT 1 test:
:UPPer	Path to configure upper limit:
[:DATA] <n>	Specify upper limit (-9.999999e35 to +9.999999e35).
[:DATA]?	Query upper limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source.
:LOWer	Path to configure lower limit:
[:DATA] <n>	Specify lower limit (-9.999999e35 to +9.999999e35).
[:DATA]?	Query lower limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.
:STATe?	Query state of limit test.
:FAIL?	Query test result (1 = pass, 0 = fail).
:CLEAR	Path to clear failed test:

Table 23. Calculate command summary (cont.)

Command	Description
:CALCulate3	
:LIMit[1]	
:CLEAR	
[:IMMediate]	Clear failed test indication.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.
:AUTO?	Query auto clear.
:LIMit2	Path to control LIMIT 2 test:
:UPPer	Path to configure upper limit:
[:DATA] <n>	Specify upper limit (-9.999999e35 to +9.999999e35).
[:DATA]?	Query upper limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source (digital output value).
:LOWer	Path to configure lower limit:
[:DATA] <n>	Specify lower limit (-9.999999e35 to +9.999999e35).
[:DATA]?	Query lower limit.
:SOURce <NRf>	Specify digital output (0 to 15).
:SOURce?	Query source (digital output value).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) limit test.
:STATe?	Query state of limit test.
:FAIL?	Query test result (1 = pass, 0 = fail).
:CLEAR	Path to clear failed test:
[:IMMediate]	Clear failed test indication.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto clear.
:AUTO?	Query auto clear.
:PASS	Path to define "pass" digital output pattern.
:SOURce <NRf>	Specify digital output (0 to 15).
:CLIMits	Command path for composite limits:
:FAIL?	Query composite result of LIMIT 1 and LIMIT 2 tests (1 = pass, 0 = fail).
:BSTRobe	Path to control limit binning strobe:
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) strobe.
:STATe?	Query state of binning strobe.
:IMMediate	Re-perform limit tests.

Table 24. CALibrate command summary

Command	Description
:CALibration	Calibration root command.
:PROTected	All commands in this subsystem are protected by the CAL switch.
:LOCK	Lock out calibration (opposite of enabling cal with CAL switch).
:SWITch?	Request comprehensive CAL switch state. (0 = locked; 1 = unlocked)
:SAVE	Save cal constants to EEPROM.
:DATA?	Download cal constants from 2001.
:DATE "<string>"	Send cal date to 2001.
:DATE?	Request cal date from 2001.
:NDUE "<string>"	Send next due cal date to 2001.
:NDUE?	Request next due cal date from 2001.
:LLEVel	Low-level calibration subsystem.
:SWITch?	Request low-level CAL switch state. (0 = locked; 1 = unlocked)
:STEP <Step #>	
1	20V AC at 1kHz step.
2	20V AC at 30kHz step.
3	200V AC at 1kHz step.
4	200V AC at 30kHz step.
5	1.5V AC at 1kHz step.
6	0.2V AC at 1kHz step.
7	5mV AC at 100kHz step.
8	0.5mV AC at 1kHz step.
9	+2V DC step.
10	-2V DC step.
11	0V DC step.
12	20mA AC at 1kHz step.
13	+0.2A DC step.
14	+2A DC step.
15	2V AC at 1Hz step.
:STEP?	Request the current calibration step.
:CALCulate	Calculate low-level cal constants.

Table 24. CALibrate command summary (cont.)

Command	Description
:CALibration	
:PROTected	
:DC	User calibration subsystem.
:ZERO	Low-thermal short calibration step.
:LOW <NRf>	+2V DC calibration step.
:HIGH <NRf>	+20V DC calibration step.
:LOHM <NRf>	20kΩ calibration step.
:HOHM <NRf>	1MΩ calibration step.
:OPEN	Open circuit calibration step.
:CALCulate	Calculate DC cal constants.
:UNPRotected	All commands in this subsystem are not protected by CAL switch.
:ACCompensation	Perform user AC calibration (disconnect all cables).

Table 25. DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:DATA?	Query data on top portion of display.
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:DATA?	Query data on bottom portion of display.

Table 25. DISPlay command summary (cont.)

Command	Description
:DISPlay	
:CNDisplay	Clear NEXT (or PREV) display messages and cancel associated operations.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display.
:ENABle?	Query state of the display (0 or 1).

Table 26. FORMat command summary

Command	Description
:FORMat	
[:DATA] <type>[,<length>]	Select data format: ASCii REAL, 32 REAL, 64 SREal DREal
[:DATA]?	Query data format.
:ELEMents <item list>	Specify data elements: READing, CHANnel, RNUMber, UNITs, TIMEstamp and STATus.
:ELEMents?	Query data elements.
:BORDer <name>	Select binary byte order: NORMal, SWAPped.
:BORDer?	Query byte order.

Table 27. OUTPut command summary

Command	Description
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active (AHIGH) or active (ALOW).
:LSENse?	Query polarity of line 4.

Table 28. ROUTe command summary

Command	Description
:ROUTe	
:CLOSe <list>	Path and command to close specified channel:
:STATe?	Query closed channel.
:CLOSe? <list>	Query specified channels (1 = closed, 0 = open).
:OPEN <list>	Open specified channel or all channels.
:OPEN:ALL	Open all channels.
:OPEN? <list>	Query specified channels (1 = open, 0 = closed).
:SCAN	Command path to configure and control scan operations:
[:INTernal] <list>	Specify an internal scan list (2 to 10 channels).

Table 28. ROUTe command summary (cont.)

Command	Description
:ROUTe	
:SCAN	
[:INTernal]?	Query the internal scan list.
:FUNCtion <list>, <name>	Assign measurement function to specified channels.
:FUNCtion? <list>	Query function for each specified channel.
:EXTernal <list>	Specify an external scan list (2 to 80 channels).
:EXTernal?	Query the external scan list.
:FUNCtion <list>, <name>	Assign measurement function to specified channels.
:FUNCtion? <list>	Query function for each specified channel.
:RATio	Command path to configure ratio calculation:
:FUNCtion <name>	Specify function for Ratio ('VOLTage:DC', 'RESistance' or 'FRESistance').
:FUNCtion?	Query Ratio function.
:RCHannel <list>	Specify reference channel (1 to 10).
:RCHannel?	Query reference channel.
:MCHannel <list>	Specify measure channel (1 to 10).
:MCHannel?	Query measure channel.
:DELTa	Command path to configure delta calculation:
:FUNCtion <name>	Specify function for Delta ('VOLTage:DC', 'RESistance' or 'FRESistance').
:FUNCtion?	Query Delta function.
:RCHannel <list>	Specify reference channel (1 to 10).
:RCHannel?	Query reference channel.
:MCHannel <list>	Specify measure channel (1 to 10).
:MCHannel?	Query measure channel.
:LSELect <name>	Select scan operation: INTernal, EXTernal, RATio, DELTa, NONE.
:LSELect?	Query scan operation.

Table 29. Sense command summary

Command	Description
[:SENSe[1]]	
:ALTernate[1]	Path to control an Alternate setup.
:SAVE	Save current setup as Alternate setup.
:RECall	Return instrument to Alternate setup.
:FUNCtion <name>	Select measurement function: 'VOLTage:AC', 'VOLTage:DC','RESistance', 'FRESistance','CURRent:AC', 'CURRent:DC','FREQuency', 'TEMPerature'
:FUNCtion?	Query function.
:DATA	Path to select reading type:
[:LATest]?	Query the latest reading.
:FRESh?	Query a fresh reading.

Table 29. Sense command summary (cont.)

Command	Description
:CURRent:AC	Path to configure AC current.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +2.1).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.

Table 29. Sense command summary (cont.)

Command	Description
:CURRent:AC	
:RANGe	
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +2.1).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +2.1).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.

Table 29. Sense command summary (cont.)

Command	Description
:CURRent:AC	
:AVERage	
:ADVanced	
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:DETector	Path to select function:
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage.
[:FUNCtion]?	Query detector function.
:CURRent:DC	Path to configure DC current.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 2.1).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.

Table 29. Sense command summary (cont.)

Command	Description
:CURRent:DC	
:RANGe	
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1 to +2.1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.

Table 29. Sense command summary (cont.)

Command	Description
:CURRent:DC	
:AVERage	
:ADVanced	
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:METHod <name>	Select measurement technique: NORMal, ICIRcuit.
:METHod?	Query method.
:VOLTage:AC	Path to configure AC voltage.
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; 0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to +775).
[:UPPer]?	Query range.

Table 29. Sense command summary (cont.)

Command	Description
:VOLTage:AC	
:RANGe	
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to +775).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to +775).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-775 to +775).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.

Table 29. Sense command summary (cont.)

Command	Description
:VOLTage:AC	
:AVERage	
:ADVanced	
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:DETector	Path to select function:
[:FUNCtion] <name>	Select type of AC measurement: RMS, AVERage, PEAK, LFRMs, NPeak, PPeak.
[:FUNCtion]?	Query detector function.
:PWINdow <n>	Specify window in seconds (0.1 to 9.9).
:PWINdow?	Query peak spike detection window.
:VOLTage:DC	Path to configure DC voltage:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate (number of line cycles; (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.

Table 29. Sense command summary (cont.)

Command	Description
:VOLTage:DC	
:NPLCycles <n>	
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 1100).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 1100).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 1100).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-1100 to +1100).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.

Table 29. Sense command summary (cont.)

Command	Description
:VOLTage:DC	
:AVERage	
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:RESistance	Path to configure resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:RANGe	Path to configure measurement range:

Table 29. Sense command summary (cont.)

Command	Description
:RESistance	
:RANGe	
[:UPPer] <n>	Select range (0 to 1.05e9).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 1.05e9).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 1.05e9).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-1.05e9 to +1.05e9).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).

Table 29. Sense command summary (cont.)

Command	Description
:RESistance	
:AVERage	
:ADVanced	
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.
:OCOMpensated?	Query Offset Compensation.
:FRESistance	Path to configure four-wire resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.

Table 29. Sense command summary (cont.)

Command	Description
:FRESistance	
:RANGe	Path to configure measurement range:
[:UPPer] <n>	Select range (0 to 2.1e5).
[:UPPer]?	Query range.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto range.
:AUTO ONCE	Set range based on present input signal.
:ULIMit <n>	Specify upper limit for auto range (0 to 2.1e5).
:ULIMit?	Query upper limit.
:LLIMit <n>	Specify lower limit for auto range (0 to 2.1e5).
:LLIMit?	Query lower limit.
:AUTO?	Query auto range.
:REFerence <n>	Specify reference (REL) value (-2.1e5 to +2.1e5).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 to 8).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count
:ADVanced	Path to configure and control advanced filter.
:NTOLerance <n>	Specify noise tolerance level (0 to 100 percent).

Table 29. Sense command summary (cont.)

Command	Description
:FRESistance	
:AVERage	
:ADVanced	
:NTOLerance?	Query noise tolerance level.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) advanced filter.
[:STATe]?	Query state of advanced filter.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:OCOMpensated <b>	Enable (1 or ON) or disable (0 or OFF) Offset Compensation.
:OCOMpensated?	Query Offset Compensation.
:FREQuency	Path to configure frequency:
:COUPling AC|DC	Specify input coupling.
:COUPling?	Query input coupling.
:REFerence <n>	Specify reference (REL) value (0 to 15e6).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.
:DIGits <n>	Specify measurement resolution (4 or 5).
:DIGits?	Query resolution.
:SOURce <name>	Select source: CURRent, VOLTage.
:SOURce?	Query source.
:THReshold	Path to configure threshold:
:CURRent	Path to set current threshold:
:RANGe <n>	Specify range (0 to 1).
:RANGe?	Query range.

Table 29. Sense command summary (cont.)

Command	Description
:FREQuency	
:THReshold	
:CURRent	
:LEVel <n>	Specify threshold level.
:LEVel?	Query threshold level.
:VOLTage	Path to set voltage threshold:
:RANGe <n>	Specify range (0 to 1000).
:RANGe?	Query range.
:LEVel <n>	Specify threshold level.
:LEVel?	Query threshold level.
:TTL	Set threshold to TTL level.
:TEMPerature	Path to configure four-wire resistance:
:APERture <n>	Specify integration rate in seconds (166.67e-6 to 200e-3).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto aperture.
:AUTO ONCE	Enable and then disable auto aperture.
:AUTO?	Query auto aperture (0 or 1).
:APERture?	Query aperture (integration rate).
:NPLCycles <n>	Specify integration rate in number of line cycles (0.01 to 10).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto NPLC.
:AUTO ONCE	Enable and then disable auto NPLC.
:AUTO?	Query auto line cycle integration (0 or 1).
:NPLCycles?	Query line cycle integration rate.
:REFerence <n>	Specify reference (REL) value.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) REL.
:STATe?	Query state of REL (0 or 1).
:ACQuire	Use input signal as reference.
:REFerence?	Query reference (REL) value.

Table 29. Sense command summary (cont.)

Command	Description
:TEMPerature	
:DIGits <n>	Specify measurement resolution (4 to 7).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto resolution.
:AUTO ONCE	Enable and then disable auto resolution.
:AUTO?	Query auto resolution (0 or 1).
:DIGits?	Query resolution.
:AVERage	Path to configure and control the filter.
:TCONtrol <name>	Select filter type: MOVing, REPeat.
:TCONtrol?	Query filter type.
:COUNt <n>	Specify filter count (1 to 100).
:COUNt?	Query filter count.
[:STATe] <b>	Enable (1 or ON) or disable (0 or OFF) filter.
[:STATe]?	Query state of digital filter.
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto filter.
:AUTO ONCE	Enable and then disable auto filter.
:AUTO?	Query auto filter.
:TRANsducer <name>	Select transducer: RTD, FRTD, TCouple.
:TRANsducer?	Query transducer.
:RTD	Path to configure RTD measurements:
:TYPE <name>	Select RTD parameters: PT385, PT3916, USER.
:TYPE?	Query RTD type.
:ALPHa <NRf>	Specify constant for USER type (0 to 0.01).
:ALPHa?	Query alpha.
:BETA <NRf>	Specify constant for USER type (0 to 1).
:BETA?	Query beta.
:DELTa <NRf>	Specify constant for USER type (0 to 5).
:DELTa?	Query delta.
:RZERo <NRf>	Specify constant for USER type (0 to 1000).
:RZERo?	Query rzero.

Table 29. Sense command summary (cont.)

Command	Description
:TEMPerature	
:TCouple	Path to configure TC measurements:
:TYPE <name>	Select thermocouple type: J, T, K, E, R, S, B.
:TYPE?	Query TC type.
:RJUNctionX	Path to configure reference junctions (Z = 1 to 5).
:RSELect <name>	Select reference type: SIMulated, REAL.
:RSELect?	Query reference type.
:SIMulated <n>	Specify simulated rempera-ture.
:SIMulated?	Query simluated tempera-ture.
:REAL	Command path to specify "real" reference junction.
:TCOefficient <n>	Specify TC.
:TCOefficient?	Query TC.
:OFFSet <n>	Specify voltage offset at 0°C.
:OFFSet?	Query voltage offset.
:ACQuire	Update reference tempera-ture.
:SENSe2	
:TTL[1]	Path to read digital input port:
:DATA?	Query (read) the digital input port.

Table 30. SOURce command summary

Command	Description
:SOURce	
:TTL[1][:LEVel] <b>	Set digital output line #1 true (1 or ON) or false (0 or OFF).
:TTL[1][:LEVel]?	Query digital output line 1.
:TTL2[:LEVel] <b>	Set digital output line #2 true (1 or ON) or false (0 or OFF).
:TTL2[:LEVel]?	Query digital output line 2.
:TTL3[:LEVel] <b>	Set digital output line #3 true (1 or ON) or false (0 or OFF).
:TTL3[:LEVel]?	Query digital output line 3.
:TTL4[:LEVel] <b>	Set digital output line #4 true (1 or ON) or false (0 or OFF).
:TTL4[:LEVel]?	Query digital output line 4.

Table 31. STATus command summary

Commands	Description
:STATus	
:MEASurement	Path to control measurement event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:OPERation	Path to control operation event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.

Table 31. STATus command summary (cont.)

Commands	Description
:STATus	
:OPERation	
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.

Table 31. STATus command summary (cont.)

Commands	Description
:STATus	
:OPERation	
:TRIGger	
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Read the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Read the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:CONDition?	Read the condition register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Read the most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Read the enabled messages.
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Read the disabled messages.
:CLEar	Clears all messages from Error Queue.

Table 32. SYSTem command summary

Command	Description
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.
:POSetup?	Query power-on setup.
:FRSWitch?	Query INPUTS switch (0 = rear, 1 = front).
:VERSion?	Query revision level of SCPI standard.
:ERRor?	Query (read) Error Queue.
:AZERo	Path to set up auto-zero.
:TYPE <name>	Select auto-zero mode: NORMal, SYNChronous.
:TYPE?	Query auto-zero mode (0 or 1).
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) auto-zero.
:STATe?	Query auto-zero (0 or 1).
:AMEThod <name>	Select reading acquisition method: BURSt, NORMal, ASTReam, SSTReam.
:AMEThod?	Query acquisition method.
:LSYNc	Path to control line synchronization of measurements.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) line sync.
:STATe?	Query line sync (0 or 1).
:KEY <NRf>	Simulate key-press (1 to 31).
:KEY?	Query the last "pressed" key.
:CLEar	Clears messages from the Error Queue.
:FETCh	Path to set fetch format.
:FORMat <name>	Select format for :FETCh? command; SCPI or FRESh.

Table 33. TRACe command summary

Command	Description
:TRACe|:DATA	Use :TRACe or :DATA as root command.
:CLEar [BUFFER,]	Clear readings from buffer.
:FREE? [BUFFER,]	Query bytes available and bytes in use.
:EGRoup [BUFFER,] <name>	Select element group: FULL, COMPact.
:EGRoup? [BUFFER,]	Query element group.
:POINts [BUFFER,] <n>	Specify size of buffer.
:AUTO [BUFFER,] <b>	Enable (1 or ON) or disable auto buffer sizing.
:AUTO? [BUFFER,]	Query state of auto buffer sizing.
:POINts? [BUFFER,]	Query buffer size.
:FEED [BUFFER,] <name>	Select source of readings: SENSe[1], CALCulate[1], NONE.
:PRETrigger	Path to configure pre-trigger storage mode.
:AMOunt	Path to specify number of pre-trigger readings.
[:PERCent] [BUFFER,] <n>	Specify as a % (0 to 100) of buffer.
[:PERCent]? [BUFFER,]	Query percentage.
:READings [BUFFER,] <n>	Specify as a number.
:READings? [BUFFER,]	Query number of readings.
:SOURce [BUFFER,] <name>	Select pre-trigger source event:EXTernal, TLINk, BUS, MANual.
:SOURce? [BUFFER,]	Query pre-trigger source event.
:CONTrol [BUFFER,] <name>	Select buffer control mode:NEVer, NEXT, ALWays, PRETrigger.
:CONTrol? [BUFFER,]	Query buffer control mode.
:FEED? [BUFFER,]	Query source of readings for buffer.
:DATA? [BUFFER,]	Read all readings in the buffer.

Table 34. Trigger command summary

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Loop around control source.
:COUNt <n>	Program arm count (1 to 99999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:LAYer2	Path to program arm layer 2:
:IMMediate	Loop around control source.
:COUNt <n>	Program scan count (1 to 99999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 999999.999 sec).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 999999.999 sec).
:TIMer?	Query timer.
:SIGNal	Loop around control source.

Table 34. Trigger command summary (cont.)

Command	Description
:ARM[:SEQuence[1]]	
:LAYer2	
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Loop around control source.
:COUNt <n>	Program measure count (1 to 99999, or INF).
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 999999.999 sec).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 999999.999 sec).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.
:PROTocol?	Query protocol.
:DIRection <name>	Enable (SOUR) or disable (ACC) Bypass: SOURce, ACCeptor.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.

Table 34. Trigger command summary (cont.)

Command	Description
:TRIGger[:SEQuence[1]]	
:TCONfigure	
:SSYNchronous	Path to configure semi-synchronous Trigger Link:
:LINE <NRf>	Select trigger line (1 to 6).
:LINE?	Query trigger line.

Table 35. UNIT command summary

Command	Description
:UNIT	
:TEMPerature <name>	Select temperature measurement units: C, CEL, F, FAR, K.
:TEMPerature?	Query temperature units.
:VOLTage	Path to configure ACV units.
:AC <name>	Select ACV measurement units: V, DB, DBM.
:DB	Path to set DB reference voltage.
:REFerence <n>	Specify reference in volts.
:REFerence?	Query DB reference.
:DBM	Path to set DBM reference impedance.
:IMPedance <n>	Specify reference impedance.
:IMPedance?	Query DBM reference impedance.
:AC?	Query ACV units.

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